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Qualitative Reconceptualizations of Success in Physics From a Feminist Lens

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QUALITATIVE RECONCEPTUALIZATIONS OF SUCCESS IN PHYSICS FROM A FEMINIST LENS

by

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ABSTRACT

To address the critical issue of the underrepresentation of women in physics, the Physics Education Research community has focused on exploring the factors contributing to student success; however, few studies have explored the meaning of success in physics as seen by women and other marginalized populations. This study, guided by Feminist Standpoint Theory and Critical Race Nepantlera Methodologies, incorporates qualitative methods to explore the central question, "how do women in physics conceptualize the meaning of success in physics?"

We begin with an analysis of metaphors of success in physics constructed by nine women studying physics at a single institution, followed up with a supplementary poetic analysis elaborating on a single participant's metaphor. These studies reveal a conceptualization of success in physics as a journey that incorporates the features of satisfactions, struggles, hope, and recognition while studying physics. After noticing a lack of representation of participants identifying as Latinas, we conducted complementary analysis of metaphors by 20 Latinas pursuing a degree in physics throughout the United States. The follow-up metaphor analysis expanded on the conceptualizations to include those of success in physics as building puzzles, overcoming gravity, peaceful landscapes, sports, and riding vehicles among others, used to structure concepts such as learning and contributing knowledge, overcoming struggles with social perceptions, and achieving significant milestones. This metaphor analysis was followed up with a descriptive analysis of the goals mentioned by the Latina students in

their discussions of success. The analysis revealed individual participants identifying a wide range of goals, with a noticeable prevalence of goals related to belonging, social responsibilities, resource provision, positive self-evaluation, self-determination, and happiness. In conclusion, this dissertation provides a wide range of conceptualizations to help guide and encourage educators engaging in discussions with students, especially those from marginalized backgrounds, about their success in physics with the consideration that success is a highly personal concept.

This dissertation is dedicated to my parents, Blas Francisco Zamarripa Avila and Madeline Roman Rodriguez, who literally and metaphorically sacrificed their lives for myself and my siblings to prosper; to my grandparents, Gloria, Lalo, Leonel, and Licha for all their love that made me; to El Paso, Texas and Ciudad Juarez, Chihuahua, the land, place, and people that chose me to be a part of their history and taught me how to be a traveler between worlds; to the peoples of the Tigua, Piro, Manso, Suma, Apache, Tarahumara, Jumano and other indigenous cultures who have cared for the region of El Paso del Norte since before European conquest; to all the children of the Dwight D. Eisenhower Memorial Apartments in Northeast El Paso and all other children growing up in government subsidized housing as a reminder that our voices, stories, and lives are valuable and can make this world a better place;

and if you don't know, now you know…

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CHAPTER 1: INTRODUCTION

This dissertation aims to address the critical issue of the underrepresentation of women in physics. The Physics Education Research (PER) community has focused on exploring success and self-efficacy, i.e. confidence in one's own abilities to succeed, to identify ways to increase representation; however, few studies have explored how women personally conceptualize success in physics. This study is guided by feminist theories and incorporates qualitative methods to explore the question, "how do women in physics conceptualize the meaning of success in physics?"

To begin answering this question we conducted an analysis of metaphors of success in physics constructed by women studying physics at a single institution, followed up with a supplementary poetic analysis elaborating on a single participant's metaphor. These studies reveal conceptualizations of success in physics that can be used to frame discussions of success with the consideration of women's views.

The next studies further focus on participants identifying as Latinas studying physics in the United States as a complementary metaphor analysis due to a lack of Latinx representation in the first study. The metaphor analysis of Latina's perspectives was followed up with a descriptive analysis of the goals mentioned by the Latina students in discussions of success, to expand the goals recognized by the physics community. We begin this introduction with an explicit positionality statement of the lead researcher to make clear their intentions as well as the way their identity is intertwined with the dissertation. This is followed up by discussions

elaborating on the topics of women in physics, success in physics, the guiding frameworks and research questions addressed in this dissertation.

Women in Physics

Representation of Women in STEM and Physics

Representation of women in science, technology, engineering, and mathematics (STEM) has been rising for the last 50 years; however, those gains have remained stagnant over the last decade. Throughout that time, the percentage of STEM bachelor's degrees awarded to women in the United States increased from 17% to 36% of degrees (American Physical Society & Integrated Postsecondary Education Data System, 2021; Porter & Ivie, 2019). In physics, the proportion of degrees awarded to women grew from less than 5% in 1966 to 23% of bachelor's degrees and from near 2% to 20% of PhDs according to the most recent report on women in astronomy and physics by the American Institute of Physics (Porter & Ivie, 2019). For Women of Color, there is an even lower representation, with only 4% of women earning a physics bachelor's identifying as Black and 7% as Hispanic. The representation of women earning degrees in fields such as chemistry and biology is closer to 50%, as seen in figure 1, yet the low numbers of women earning degrees in other STEM fields is an ongoing concern. Consequently, it has become a central issue for physics education researchers to understand what has led to the underrepresentation of women and gender minorities in physics and to determine what can be done to change it (Brewe & Sawtelle, 2016; A. L. Traxler et al., 2016).

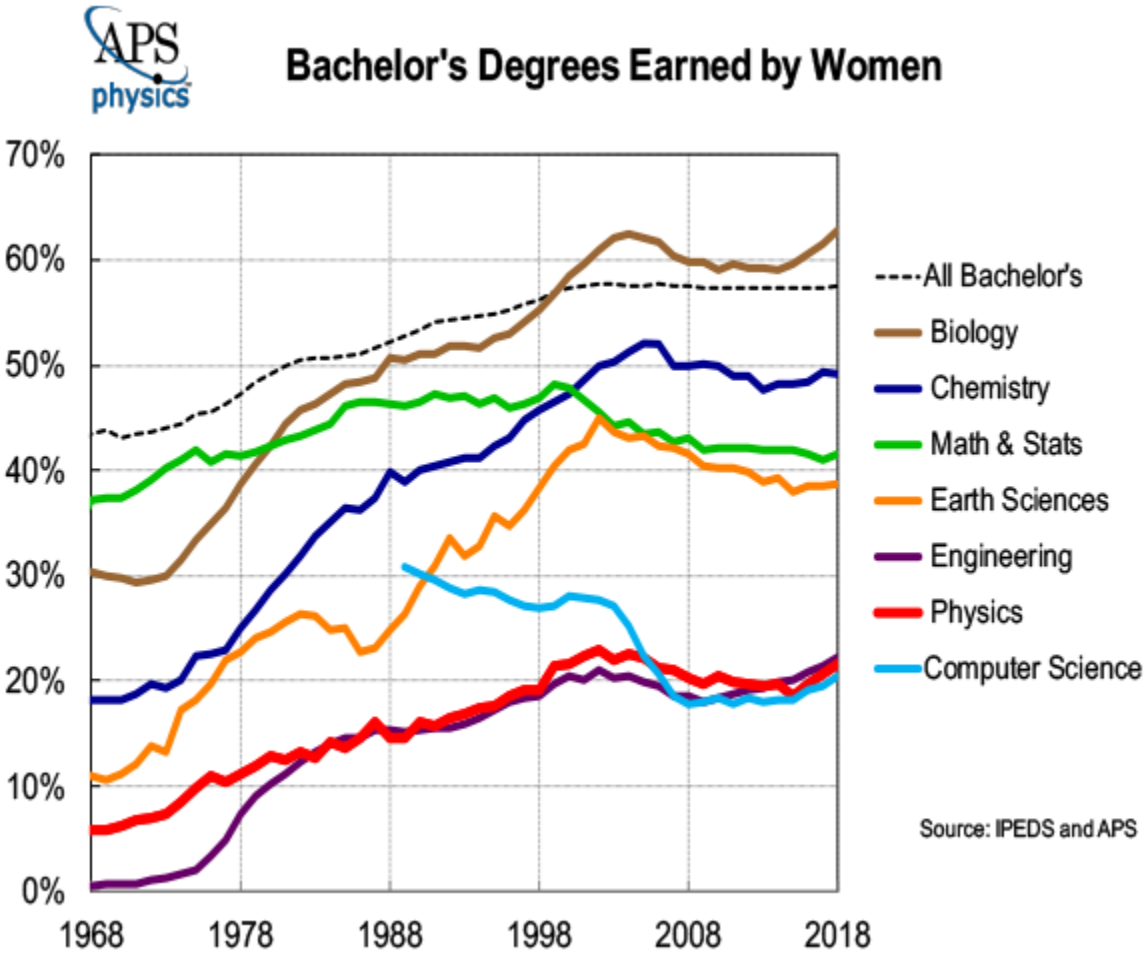

Figure 1: Bachelor's Degrees Earned by Women (American Physical Society & Integrated Postsecondary Education Data System, 2021)

Bias and Sexism Impacting Women in Physics

In the last decade Hill, Corbet, and St. Rose (2010) released an extensive report identifying factors contributing to the underrepresentation of women pursuing STEM careers. The report discusses contributing factors, such as beliefs about intelligence, spatial skills, stereotypes, department culture, and biases. It is noted that stereotypes form a basis for other factors, such as negative self-assessments and implicit/workplace biases. Gendered

stereotypes of femininity, such as subjectivity, feelings, and nurturing, stereotypes of women not being good at math and science, and stereotypes of math and science as a masculine fields dealing with objectivity, reason, and mind, better suited for men (Carli et al., 2016; Hill et al., 2010; Keller, 1985; Kessels et al., 2006), result in conflicts putting women at odds with their pursuits of STEM careers These conflicting stereotypes thus lead women to experience psychological distress, such as stereotype threat (feeling at risk of conforming with negative stereotypes about oneself) (Easterly & Ricard, 2020; Marchand & Taasoobshirazi, 2013; S. J. Spencer et al., 1999) and impostor phenomenon (feeling like one will be found to not belong in a setting) (Chrousos & Mentis, 2020; O'Connell et al., 2020; Slank, 2019).

Stereotypes additionally contribute to social factors hindering women's participation in the form of workplace biases, including receiving less feedback, encouragement, and eye contact from colleagues, as well as being called upon less, interrupted more, and discouraged from sciences more often than men (R. M. Hall & Sandler, 1982; Hill et al., 2010). These biases are examples of what is historically referred to as the "chilly climate" negatively impacting women throughout academia (R. M. Hall & Sandler, 1982; Miner et al., 2019; Sandler & Hall, 1986).

Women in physics must also deal with varying degrees of gender-based discrimination from microagressions (i.e., subtle acts of discrimination) to overt sexism and sexual harassment (Aycock et al., 2019; Barthelemy et al., 2016). Microagressions include subtle discrimination in the form of invisibility (i.e., not being recognized for their contributions), second-class citizenship (i.e., not given access to equal resources or opportunities as men), as well as sexist

and objectifying language, (Barthelemy et al., 2016). Women must also deal with overt sexism and sexual harassment, including stalking and sexual assault (Barthelemy et al., 2016), which studies have reported is a widespread issue since 75% of the 455 undergrad women in physics surveyed experienced some form of sexual harassment (Aycock et al., 2019). In order to mitigate the negative impacts of dealing with these experiences, women often find themselves negotiating aspects of their femininity to survive in physics contexts (Danielsson, 2012; Gonsalves, 2014; Steele, 1997) or leaving the field (Lewis et al., 2016; Towns, 2010).

Assessments and Content Not Designed for Women

It is necessary to emphasize women are not in conflict with physics. Instead, we recognize that physics culture tends towards masculinity (Schiebinger, 1999), even as many physicists believe that physics is a culture of no culture (Traweek, 2009). This bias towards masculinity is reflected in the factors above and in assessments and the presentation of physics content as discussed below.

One example of masculine bias is the Colorado Learning Attitudes about Science Survey (CLASS) that was developed as a method to assess students' attitudes and beliefs about physics (Gray et al., 2008). In the survey, students respond to 42 Likert-scale items that are compared to a set of expert responses, which are then scored by percent agreement with the experts. The problem with this method is that no demographic information was available about the experts, and, given the demographics of physics (Porter & Ivie, 2019), the expert participants in the

study were likely majority men. Implementations of the CLASS have noted women scoring lower than men, yet it is unclear if this is due to uninvestigated gender biases.

Physics content biased towards masculinity can also be seen in widely used assessments like the Force Concept Inventory (FCI, Hestenes et al., 1992). Implementations of the FCI have resulted in noticeable "gaps" in performance, with women "underperforming" compared to men (J. Docktor & Heller, 2008). Early iterations of the FCI were noticed by McCullough to have a prevalence of masculine content, such as cannonballs, hockey, and rockets, which led to a revised FCI (RFCI) to reflect more feminine content (McCullough, 2004). Women did not score significantly higher in the RFCI than the FCI; however, the difference in scores by gender was smaller in the RFCI. Although this context change did not affect women, the results suggest that context matters and that it often favors men.

It is worth noting that we discuss achievement gaps in the context in which they were originally brought up, but we understand that it can be detrimental to make these comparisons as they may lead to deficit model thinking in which we want women to be more like men. It is necessary and even recommended to rise above the "gender gap" framework to effectively deal with the underrepresentation of women in physics (A. L. Traxler et al., 2016). Alternative frameworks that can address the factors leading to underrepresentation include anti-deficit frameworks that explore the strengths of marginalized individuals and critical frameworks that more directly critique the systems marginalizing individual (Mejia et al., 2018). It is useful to move towards more critical approaches to transform oppressive systems, however we

recognize that such change takes extended amounts of time, while anti-deficit approaches can lead to more immediate benefits for the individuals going through the systems.

Considering nearly 2,000 women earned their physics degrees in 2018 (APS & IPEDS, 2021) we find it necessary to transform the culture of physics so that less women have to experience sexism while pursuing a degree in physics. Addressing the issue of overt sexism is necessary; however, it is beyond the scope of this study. We recognize that shifting stereotypes, due to their contribution to sexist environments, is a valuable way to interrupt the invisibility of women's perspectives. To go beyond gap analysis of assessments scores as a measure of student success, we seek to center women's perspectives about success in physics to reframe and elaborate on the concept.

Success in Physics

Success is important as we often talk about becoming successful physicists. It is a key component in understanding self-efficacy, or the confidence in one's ability to succeed in a task (Bandura, 1977). There is a substantial body of work in physics addressing self-efficacy as it is a strong predictor of career choice and physics understanding, which can lead to retention of women in physics (Kelly, 2016; Louis & Mistele, 2012; Nissen & Shemwell, 2016; Sawtelle et al., 2012). However, it is also documented that women tend to report lower levels of self-efficacy compared to men in physics courses (Fencl & Scheel, 2005; Kost-Smith, 2011; Marshman et al., 2018; Nissen & Shemwell, 2016).

Since stereotypes and physics content are often biased towards men, we recognize that abstract social constructs, such as success, are also likely biased towards masculine perspectives. Reviewing the most cited literature in reputable physics education research journals for things that are deemed a "success" for students quickly reveals that the term "success" is often used without any explanation of its meaning, is used to refer to students attaining favorable assessment scores or course grades, or is used to refer to students completing a degree (Adams et al., 2006; Ding & Beichner, 2009; J. L. Docktor & Mestre, 2014; Etkina et al., 2006; Henderson et al., 2012; Kost et al., 2009; Madsen et al., 2013; Tuminaro & Redish, 2007). A deeper search of the literature reveals investigators seeking more explicit measures of success to include aspects such as assessments of participation and changes in attitudes among others (Goertzen et al., 2013; Norvilitis et al., 2002; Sadler & Tai, 2001; Sawtelle, 2011). This lack of operationalizations of success raises alarms when there is much emphasis on increasing the representation of women and having them succeed, yet there is no clear interpretation of what success *is*. I argue that since success is so important, there should be more work expanding our perspectives of success in physics beyond the imposed definitions of educators and including the perspectives of students themselves.

Social scientists argue that achieving success as a minority in college is often due to assimilation of dominant values like individualism (Bernal et al., 1991; MacLeod, 2018). This argument has been challenged by studies that have found Latinas in college succeeding while maintaining membership and values as Latinas (Barajas & Pierce, 2001). Thus, "success" is not necessarily predicted by assimilation, although assimilating to dominant values can lead to

dominant standards of success. Women in physics may still hold on to feminine values that do not align with male-dominant values. Work in sociology has found women tend to find success through balance and relationships, while men tend to find success through material possessions and being the bread winners (Barajas & Pierce, 2001; Dries et al., 2008; Dyke & Murphy, 2006; Orser & Leck, 2010). This is in-line with Diekman's findings of women in science having more communal goals as opposed to agentic goals when compared to men (Diekman et al., 2011). Thus, it is likely that a misalignment of traditional views and women's views of success may contribute to differences in measures of women's self-efficacy in physics compared to men, since "succeeding" at a task could mean different things for women.

Recently, concerns of misalignment between traditional views of success and minoritized people's perspectives are addressed by Rosa and Mensah (2021) in their invitation to the science education community to critically ask ourselves, "What are we considering success? Who defines what success is and what is not?" Furthermore, we ask ourselves the question posed by Traxler, et al., (2016) "Is the goal to change women so that they can succeed in a culture where men are successful, or would it be better to change the culture so that the experience of (straight white married male) men is not the assumed standard?" (p. 9). Therefore, this dissertation seeks to expand traditional views of success in the physics community with an explicit focus on women's perspectives to support the attainment of their success, as they may define it.

Guiding Frameworks

Philosophical Assumptions

This work is a response to a call to increase a focus on theoretically backed feminist qualitative studies in physics (A. Traxler et al., 2018). Due to the prevalence of recurrence-oriented quantitative research in PER, it is necessary for case-oriented qualitative studies, such as this one, to be explicit about the philosophical assumptions guiding the work (Robertson et al., 2013). This work is guided by epistemological assumptions that knowledge is socially constructed and that people in marginalized positions have relevant perspectives, in line with transformative and critical frameworks (Cresswell & Poth, 2016; Denzin & Lincoln, 2017). We recognize that individuals' experiences shape their subjective reality and recognize the validity of their perspectives. In addition, we respect participants' values and attempt to be respectful to their values through the research process. Our philosophical assumptions contribute to our choice to bring attention to the goals of women in physics via participatory qualitative methods guided by feminist frameworks to center their voices and explore rich descriptions of their perspectives.

Feminist Standpoint Theory

Feminist Standpoint Theory (FST) is useful to recognize the voices of the participants and minimize the influence of the researcher's biased perspectives (Anderson, 2020; Harding, 2007). FST makes three claims; 1) knowledge is socially situated; 2) marginalized groups are positioned in such ways that they have a heightened awareness of reality over the group doing

the marginalizing; and 3) knowledge should be created from the standpoint of the oppressed. With these claims, FST brings forth power relationships between the researcher and the researched. For this reason, a positionality statement with regards to this study is written in the following section to achieve a strong objectivity (Harding, 2007) and close contact is maintained with participants and other woman scholars to ensure participants' voices are faithfully represented.

Gender Performativity

The framework of gender performativity is useful to recognize there is more to gender than dichotomous labels based on biological differences. Judith Butler's use of gender performativity to expand on gender as a social construct describes how one's gender is constructed through performing gendered acts (Butler, 1988, 2011). These gendered acts, consisting of masculinities and femininities, are not limited to men and women. This means people of any gender may partake in masculinities and femininities, and through enacting these qualities an individual's gender is produced. This framework allows us to make sense of a world in which gender is a continuously dynamic concept. Having this perspective that people perform masculinities and femininities also allows us to explore women's perspectives with the recognition that people of all genders may benefit from making femininities more accepted in their contexts.

Intersectionality

We acknowledge that women's identities are more complex than the single label under the dimension of gender, which leads us to approach the study through an intersectional lens. While women may generally experience discrimination based on their identity as women, their individual experiences may vary drastically as a result of other aspects of identity, such as race, ethnicity, socioeconomic status, sexuality, and disability (Crenshaw, 1989). For this reason, it is important to recruit women of diverse backgrounds, to be vigilant of instances where intersectionality may be at play, and to be careful with claims and who they apply to. We recognize a need to explore success in physics with intersectionality as an analytical lens; however, an intersectional analysis considering the direct influences of the multiple dimensions of oppressive systems is outside the scope of this study.

Positionality

To begin this dissertation, it is necessary to explicate my position in this study, specifically that of being a Mexican-Puerto Rican person raised as a cis-gendered man conducting research to support women in physics. I will explain my personal motives to conduct this study, the ways that my identity can be beneficial to this research, and the limitations of my involvement.

The relationship between researchers and those researched has been heavily influenced by imperialist traditions (Smith, 2021). The researcher tends to explore the territories of those being researched, discover the riches of information possessed, interpret that information

through the colonialists' perspective, and then take it back to the researcher's homeland for the profit of the researcher. In a similar way, this happens as people with privilege study marginalized populations, such as rich people studying poor people, white people studying Black people, and in the case of this study, a man studying women (Harding, 2007). Keeping the above in mind leads me to honestly inspect the question, "Why do I, someone who is not a woman, want to study the perspectives of women?"

I want to pursue this study because supporting women is fundamental for supporting every individual (hooks, 2014). Personally, it has been a struggle to maintain my identity as man, knowing the harm that myself and men around me have caused to women by undermining their participation in life or their objectification through a seemingly perpetual cycle of propaganda. In order to break this cycle, I have recognized a need to contribute in transforming the systems that perpetuate the harm, from those within my identity as man to the academic systems where I see women still struggling to have full participation. I look around and I see fewer women in physics courses; I hear the way women are talked to or talked about in negative ways; I have heard people very directly doubting women's abilities to do well in physics departments. I want to change that.

My direct involvement began when guest speaker Geoff Potvin presented work by Hazari et al. (Hazari et al., 2013) highlighting the factors influencing high school girls' career interests. What stood out in this study is that having explicit discussions about the underrepresentation of women in science has significant positive influence on girls' interest in pursuing science careers. That is when I realized that I can do something to alleviate our

condition. I recognized that although women have a struggle much different than mine, it is not their responsibility to get themselves out of the situation a patriarchal society has placed them in. I did not create the patriarchal society, but I can play a part in dismantling the structures that have unjustly placed me as a man in physics above women in similar positions.

My position as a Mexican-Puerto Rican man in physics gives me resources that can be beneficial to the study. As a Mexican-Puerto Rican man, I am navigating my own struggles through this seemingly white men's field. I have experienced the negative effects of isolation, stereotype threat (S. J. Spencer et al., 2015), implicit bias (Brownstein, 2019), impostor phenomenon (Sakulku & Alexander, 2011), and overt and covert racism. These experiences have given me the perspective to empathize with others going through similar struggles. I am also familiar with the respect we deserve as people trying to rise after years of being underappreciated and oppressed. Although I may be able to relate, I will never *know* the struggles of a woman since I have been raised and seen as a man most of my life. To some extent, not knowing the struggles of women may also lead me to ask clarifying questions which can lead to more explicit discussions.

I cannot put aside the privileges afforded to me by being a man in physics. Instead, I recognize my privilege and how it can be used to amplify the voices of those that are not heard (Harding, 2007). I recognize an unfair bias towards men in scientific spaces (Keller, 1985), which gives me some degree of proximity to those who subscribe to these stereotypes. I choose to use that privilege to center women's voice in hopes that people may listen and become agents of liberation.

My involvement as a man researching women also includes limitations. I have been raised as a man and am perceived as a man, so it is likely that I will be seen as an outsider to women. Even if we have similar interests in science, my identity as a man may lead to barriers of comfort and may lead to participants being protective of personal topics and information. Additionally, I recognize that my interpretations of participants words may be inconsiderate of aspects valuable to them, hindering the goal of centering women's perspectives and ultimately hindering progress of women in science. To deal with these limitations, it is crucial that I maintain community with women throughout the study, become familiar with feminist work and practices, and involve participants throughout the project.

Research Questions

We acknowledge there is a need transform the culture of physics to increase women's representation in physics and that a factor contributing to attrition is a neglect of feminine perspectives of people in physics. We also recognize that current conceptualizations of success are vague and likely do not consider women's perspectives due to the dominance of masculinity in physics. To expand the physics community's perspectives of success, it is necessary to answer the main question – How do women in physics conceptualize success? The overarching question is answered in this dissertation with a series of four studies described below.

Considering metaphorical representations are useful for identifying the underlying structure of abstract concepts, we begin by engaging participants' conceptual structure of

success in physics through an analysis of metaphors used by women in a single physics department. Thus, the first study presented in chapter 2 is guided by the following question:

1) What are common characteristics of success in physics identified in explicit metaphors for 'success in physics' constructed by women studying physics at single institution?

Due to a lack of emotions in the researchers' interpretations of participants' metaphors in the first study, we were prompted to focus on a single participant's metaphor. This exploration provides insight into the value of analyzing interview data with arts-based approaches as well as the value of attending to knowledge garnered from the participant's emotional expressions. For this study, presented in chapter 3, we sought to answer the question:

2) What insights can we acquire about a participant's choice of metaphor for success in physics by attending to the emotions in their metaphor with a poetic analysis?

After addressing the first studies, it became apparent that there was a low number of participants to address questions regarding conceptualizations of success. In addition, there were no participants identifying as Hispanic or Latinas, which prompted us to seek a larger and more focused sample of women identifying as Latinas to address the conceptualizations of this double minoritized population of physics students. In this study, presented in chapter 4, we address the question:

3) What are common conceptualizations of success in physics identified across explicit metaphors shared by Latinas studying physics?

Our initial investigations revealed a concern with individuals managing various desired outcomes related to success in physics. Since it is our intention to expand conceptualizations of the meaning of success, we set out to explore the variety of goals that Latinas in physics value so that educators may more directly support the attainment of those goals as more Latinas join the physics community. For this last study, presented in chapter 5, we address the question:

4) What goals do Latinas in physics associate with their success?

These four questions outline the boundaries of this characterization of success as seen by women in physics. The different questions address conceptualizations of success by comparing perspectives of women at a single institution, focusing on a single participant's perspective, and comparing perspectives of a subset of women across institutions in the U.S. Although the questions are far from exhaustive with regards to the plethora of theories of motivation, we hope the pursuit of these questions about success is a starting point in reframing the narrative about success with one that explicitly includes women's views of success in physics.

CHAPTER 2: A COLLABORATIVE METAPHOR ANALYSIS

Introduction

While the physics community strives to support individuals from groups underrepresented in physics to achieve "success," our definitions of success often go unexamined. In this study, we characterize success in physics by experimenting with a collaborative metaphor analysis of elicited metaphorical expressions to explore students' conceptualizations of success in physics. Guided by Feminist Standpoint Theory, we focus on the perspectives held by nine physics students who identify as women to answer the research question, *What are common characteristics of success in physics identified in explicit metaphors for 'success in physics' constructed by women studying physics at single institution?*

Participants took part in interviews where they each constructed their own metaphors for "success in physics," then participated in a multistep co-analysis of the metaphors. In the first round of co-analysis, participants collaborated with the researcher to interpret and code their own metaphorical expressions; in the second round, they conducted a card sorting task to construct categories based on similarities across the metaphors.

A thematic analysis of the categories led to the identification of four salient characteristics of success in physics: satisfactions, struggles, hope, and recognition. We present these findings in the context of an emergent conceptual metaphor SUCCESS IN PHYSICS IS A JOURNEY. This conceptual metaphor of success in physics represents a more subjective conceptualization of success in physics prompting emotional experiences along the way, in

contrast to more objective conceptualizations of success as paths or pipelines. The identified characteristics of success in physics, represented in a diverse set of metaphors, suggest an expansion of what constitutes success in physics beyond traditional product-oriented views to acknowledge the ways in which students experience struggles, satisfaction, recognition, and hope along their journey.

Methodology

Analytical Framework: Metaphor Analysis

We used metaphor analysis, based on the theoretical foundations of conceptual metaphors by Lakoff and Johnson (2003), as a method to explore the abstract structure of success. Metaphors are a central focus of this study because of their role in organizing abstract thoughts, which can lead to actionable change. To Lakoff and Johnson, metaphors used in everyday language shape the way thoughts are organized, which in turn shapes behavior. Conceptual metaphors serve as mental models used to structure ideas of target domains (i.e., the concept to be described) in terms of source domains (i.e., a concept that is already familiar), to comprehend the complexity of the abstract target concepts more easily. For example, the conceptual metaphor (CM) of ARGUMENT IS WAR is captured in metaphorical expressions (i.e., the articulated words), such as “attacking an argument” or “shooting down an argument” to describe the dynamics of an argument. Lakoff and Johnson (2003) also argue that CM emerge from individual people’s experiences and their society. Since metaphors affect thought, which in turn affects behavior, one would expect behaviors associated with cultures

using the CM of ARGUMENT IS WAR to be different than behaviors associated with cultures using the CM of ARGUMENT IS DANCE. Additionally, understanding the metaphorical structure of success in physics could lead to insights regarding conceptualizations of success and behaviors such as engagement and persistence in physics. As Charteris-Black (2004) puts it, "novel linguistic encoding of relationships between phenomena have a heuristic role in stimulating new ways of understanding that are, in turn, the basis for new ways of thinking and acting" (p. 2).

Education researchers have used metaphor analysis to address questions regarding common conceptualizations for concepts in physics education such as learning (Scherr & Heron, 2016), physics concepts like energy (Brewe, 2011; Close & Scherr, 2015) and similar concepts in other STEM contexts (Lancor, 2014). A common method for analysis incorporates eliciting metaphors by having participants complete the sentence "(concept) is like…" with a metaphor or analogy to characterize concepts such as college reading and writing (Paulson & Armstrong, 2011), teaching and learning (de Guerrero & Villamil, 2002), and reflective thinking (Nur Ersozlu, 2013). This method of metaphor elicitation has also been conducted regarding conceptualizations of physics (Aykutlu, 2017; Çetin, 2016; Palic Sadoglu & Uzun, 2014). We recognize that the process of eliciting explicit metaphors allows participants to choose the aspects of the target domain that they want to emphasize, leading us to take a similar approach to address conceptualizations of the concept of success in physics.

Participants

We recruited women in physics in the Department of Physics at a large research-intensive, doctorate-granting university in the Southeastern United States via mass email. The email requested volunteer participation of people who identify as women in physics for a study intended to address the topic of success. Participants were given a $20 gift card for participation in the initial interview. We recruited 11 women at various stages of their career in physics: four undergraduate students, five graduate students, and two faculty. After reviewing the metaphors elicited in the first interview, researchers felt that the nature of the responses from the faculty were more literal descriptions of success in physics than those from the students. Additionally, the faculty were not available for the enhanced member-checking of their metaphors. Thus, we decided not to analyze the faculty's metaphors at this time, reducing our sample to nine student participants.

Participants were given the option to choose their own pseudonyms and self-report demographic information in response to questions regarding their career stage, race/ethnicity, sexuality, relationship status, personal socioeconomic status (SES) and family SES. Responses to demographics were generalized to maintain participant anonymity; for example, ethnicities closely tied to national origins were presented as regional ethnicities. We respect participants' choice to withhold demographic information and only present demographics relevant to the study in table 1.

Table 1: Participant demographics

Name	Career Stage	Race/Ethnicities	Personal SES	Family SES
Helen	Undergrad	White	Average	
Lynn	Undergrad	White	Below	Average
Amazonia	Grad	Afro-Caribbean	Below	Average
Citlali	Grad	White	Average	
Pluto	Grad	Middle Eastern	Below	Average
Samaria	Undergrad	South Asian	Average	
Amy	Undergrad	White	Average	Below
Renae	Grad	White		
Alberta	Grad	White	Average	

Blank cells indicate the participant did not disclose that information.

Data Collection

The lead researcher first met with the participants to collect data in the form of individual interviews to gather rich descriptions of participants perspectives of success, in line with FST (Harding, 2007). The interview, which was recorded and transcribed afterwards, followed a semi-structured interview protocol (Saldaña & Omasta, 2021) regarding the topics of success and physics. Interviews were an average of 35 minutes long. The interview protocol, presented in full in Appendix A, follows the structure of the interview protocol used by Scanlon (2017). For this study, we focus on responses to a prompt to complete the thought "Success in physics is like…" with a metaphor or an analogy.

Trustworthiness

Metaphor analysis requires high-inference interpretation; therefore, it is important that researchers have thoroughly reviewed the linguistic data and have experience in the relevant cultural contexts (Schmitt, 2015). While researchers likely have a better understanding of the literature and methods, we recognize that participants have a greater understanding of the meaning behind their own words and a greater understanding of their cultural context. Thus, collaboration with participants beyond initial metaphor elicitation is essential (Armstrong et al., 2011; Guba & Lincoln, 1988), leading us to incorporate enhanced member checks in the style of Chase (2017) and Harvey (2015). Participants were involved in the enhanced member checks to establish interpretations of their own metaphors and categorize the full set of metaphors to identify relevant characteristics in the metaphors. In the interview, a metaphor for "success in physics" was elicited and the participant mapped the target domain onto the source domain. In the metaphor interpretation meeting, the participant and researcher worked together to interpret her metaphor and identify the target domain features represented by the source domain language. In the card sorting meeting, the participant categorized the metaphors based on similarities in the selected source domains and aspects of the target domain they represented.

Analysis

The purpose of this metaphor analysis is to characterize success in physics by identifying relevant themes regarding conceptual metaphors and relationships conveyed in metaphors.

During the following two meetings, each participant collaborated with the researcher to analyze the metaphors, as described below. The outcomes from the co-analysis were then synthesized by the lead researcher.

Metaphor interpretation

Metaphor interpretation meetings were scheduled 3-6 months after the initial interview and focused on the participant interpreting their own metaphor. The researcher gave the participant an oral overview of the literature guiding the analysis, including Lakoff and Johnson's (2003) conceptual metaphor theory, Paulson and Armstrong's (2011) metaphor analysis, and Weiner's (1985) attribution theory.

Transcripts of participant's metaphors were then reviewed, with supporting audio upon participant request, to identify relevant features of their metaphor in terms of the source and target domains. For example, in Samaria's transcript, we identified her expression of 'getting some water out of a well' where the 'water' (source domain) corresponds to the target of 'knowledge.' The final interpretations in terms of the target domain were refined through an exchange of emails with participants shortly after the meeting.

After discussing the target features, the researcher and participant coded the metaphorical expressions using an a priori coding scheme discussed below. This coding provided a structure to describe the metaphors in more general terms to facilitate comparisons across metaphors. The a priori codes consisted of the following:

Ontology (process/product). Paulson and Armstrong (2011) found metaphors of college reading and writing to predominantly exhibit process (e.g., reading is like putting together a puzzle) or product (e.g., reading is like a cramp). This distinction in process versus product is reminiscent of Lakoff and Johnson's (2003) ontological metaphors which are used to describe abstract concepts in tangible terms such as substances or containers. Likewise, a metaphor describing a process is ontologically different than one describing a product. Coding metaphors as process or product is relevant in this context since traditional views of success are often product-oriented, as described above (e.g., scores on exams, degrees).

Sentiment (positive/negative/neither/both). Paulson and Armstrong (2011) also identified patterns of metaphors conveying negative, positive or neither feelings, which we refer to as sentiment. Sentiment is relevant in our context as there is a need to acknowledge some students may have troubling experiences with success in STEM (McGee & Bentley, 2017). Single expressions could be coded as both positive and negative to capture a range of sentiments in expressions.

Attributions. Weiner's (1985) attribution model suggests that attributing success to certain factors influences both expectancy of success and emotions. The expectancy and emotions then drive an individual's motivation. Common attributions include effort, ability, luck, task ease, and other people; however, we allowed for additional factors since there are many more context-specific attributions. The attributions were further coded for their controllability (controllable/uncontrollable), locus of causality (internal/external), and stability (stable/unstable). As an example, for a particular metaphor, the researcher and participant

coded attributions to learning ability as internal (a personal trait), controllable (the person can find ways to learn), and unstable (the person can get better at learning).

Identification of relevant themes through card sorting

A more traditional approach to metaphor analysis is to identify recurring themes in large sets of metaphorical expressions (de Guerrero & Villamil, 2002; Palic Sadoglu & Uzun, 2014; Paulson & Armstrong, 2011). However, due to the low number of metaphors collected we were led to seek a large set of feedback by asking each of the nine participants to help identify themes relevant to them, in line with our guiding principles of FST (Harding, 2007). These contributions consisted of individual personal meetings scheduled one month after the last interpretation meeting. To gather and organize the feedback, participants were ask to think aloud while reviewing the nine metaphors and then to categorize the metaphors with an open card sorting method (D. Spencer, 2009; D. Spencer & Warfel, 2004).

First, participants read the nine metaphor responses in full. Then the metaphors were presented on two-sided cards, where one side displayed the main concept of the metaphor in a few words summarized by the researcher and the other side contained the first 125 words of the metaphor transcript. The researchers asked participants to generate categories of the metaphors by grouping sets of similar metaphors and providing a label for the set. Participants were given the option to place metaphors in multiple categories to make space for different types of similarities and to account for the low number of metaphors.

Synthesis

To synthesize the card sorting, researchers identified themes from the categories based on commonly grouped metaphors and participant descriptions of the categories. Identification of commonly grouped metaphors consisted of counting the frequency of specific sets of metaphors (e.g., for a hypothetical group containing metaphors A, B, & C, the set ABC is counted once), and then counting the frequency of subsets of metaphors grouped within larger sets (e.g., for set ABC, we count the subset pairs AB; BC; & AC once each). Subsets were disaggregated by size (i.e., separating metaphor pairs and triads). Once the commonly grouped metaphors were identified, the category labels and descriptions were reviewed to contextualize the similarities in terms of conceptual metaphors and underlying characteristics of success.

Findings

The following section presents the nine metaphors of success in physics, the metaphor interpretations, results from the card sorting, relevant characteristics of success in physics, and concludes with two participants' experiences with a professor's rigid views of success. The relevant characteristics of success consist of an overarching conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY and features of satisfaction, struggles, hope, and recognition along the journey.

Metaphors and Interpretations

Participants provided metaphors varying in length, from a few sentences up to several paragraphs of explanation. In table 2 we present short expressions representative of the full responses during the interview. Longer excerpts of the metaphors are presented in Appendix B. These expressions are coupled with the co-generated interpretations informed by the discussions of the target/source domains and the *a priori* coding of the metaphorical expressions. The coding is presented in full in Appendix C and is incorporated to elaborate on the characteristics of success in physics in the section further below.

Table 2: Metaphor expressions for success in physics and their interpretations

Metaphorical Expressions Success in physics is like…	**Interpretation**
Helen: …whenever you clean off your desk and everything is clean and organized, you're like everything fits together nicely and it's just like, Yeah!	… the satisfaction that comes from solving any problem that comes up and understanding the problem variables and relationships between them.
Lynn: …a caramel apple. It's pretty sweet, but once you bite into it, it's some tartness. It's not always easy to get through it, it could get a little messy. But I think overall, it's a very good dessert.	… the combination of the struggle and satisfaction of trying to make sense of the world that makes physics so rewarding.
Amazonia: …winning the lottery. You win the lottery, so you get it, so you get your physics degree, now you gotta invest and flip it.	… obtaining a physics degree and using it to gain access to careers, including those not traditionally associated with physics.
Citlali: …the exhilaration of jumping out of an airplane. It's that rush!... When everything goes right, I mean, it's a rush!	… the exhilaration that emerges from observing unprecedented results in a project that you developed.
Samaria: …dragging a pail and getting some water out of a wishing, like a well. But like, but just like using like a cup… and you just keep trying to get more water.	… a continuous process of gaining knowledge. However, we cannot gain all the knowledge due to our limited learning abilities.

Metaphorical Expressions Success in physics is like…	**Interpretation**
Pluto: …you're an actor, and everyone watches your movie on the theater. [Actors] just present themselves somehow in different movies, and everyone sees that, and everyone enjoys that.	… presenting your best work to the physics community and the general public and having them enjoy it.
Amy: …a dandelion, because it starts with just this little idea. And then it grows into these possibilities. And all you have to do is breathe and then they go into the universe, to be explored by other people.	… developing ideas about the universe, discussing the ideas, and sharing those ideas to further be developed by the community and the general public.
Renae: …running into a door, knowing that at the end the door will be opened for you, but you have to keep running into it.	… confronting difficulties, while knowing her professor will recognize the effort and allow her to pass.
Alberta: …running a marathon. No one thinks it is easy and when you're done you get a medal to show off, but the real work starts long before race day.	… preparing a project long before presenting a final product and taking the chance to present project outcomes.

Card Sorting Frequencies

In total, the participants created 50 categories between the 9 metaphors. Each metaphor was placed in an average of 17.7 categories, with the metaphor for ***Being an actor*** being grouped the fewest times in 14 categories, while ***Running into a door*** and ***Running a marathon*** were grouped the most times in 21 categories each. The full set of categories generated by each participant, with the category labels and the metaphors assigned to each category, is included in Appendix D. The number of times participants grouped pairs or triads of metaphors was counted to explore the similarities participants recognized. Results of frequencies are summarized in table 3 and discussed in more detail below.

The most common group of metaphors was ***Dragging a pail to get water from a well, Running into a door*** and ***Running a marathon*** (set: EHI). This set includes the most frequent metaphor pair of ***Dragging a pail to get water from a well*** and ***Running into a door*** (pair EH), which were grouped at least once by each participant. ***Running a marathon*** was grouped with the other two metaphors by all participants except Alberta (pairs EI; HI). Labels to categories made of this subset included "exhausting," "slow work," "painful process" and "a punishment."

The second most common set was that of ***Having a clean desk, Jumping out of a plane,*** and ***Blowing a dandelion*** (ADG), which were grouped by four of the participants (Citlali, Samaria, Amy, and Alberta) a total of seven times. Categories containing this set of metaphors

were given labels such as "feeling/emotion," "satisfaction," "pleasure" and "upbeat accomplishment."

Related to these two groups, it is worth noting that only two pairs of metaphors were never grouped a single time: ***Blowing a dandelion*** was never paired with ***Dragging a pail to get water from a well*** (EG) or ***Running into a door*** (EI). This lack of grouping indicates a clear distinction between the metaphors.

The next most common set of ***Winning the lottery*** and ***Blowing a dandelion*** (set: CG) was grouped by four participants (Lynn, Amazonia, Samaria, and Renae) and an additional three participants paired them under larger sets (Helen, Citlali, and Amy). Groups including this pair were given labels such as "passive," "inactive," "hoping for a wish" and "taking a chance."

Table 3: Frequency of metaphor groups.

Pairs	**Number of people** (total times grouped)	**Triads**	**Number of people** (total times grouped)
EH	9 (16)	EHI	8 (13)
HI	8 (16)	ADG	4 (7)
EI	8 (14)	EFH	4 (7)
CG	7 (9)	ABD	4 (4)
BD	7 (7)	ACG	4 (4)
AD	6 (11)	BDG	4 (4)
DG	6 (10)	CDG	4 (4)
AG	5 (8)		
…	…		
FG	1 (1)		
EG	0		
GH	0		

Metaphor key: A) Having a clean desk; B) Biting a caramel apple; C) Winning the lottery; D) Exhilaration of jumping out of a plane; E) Dragging a pail to get water from a well; F) Being an actor; G) Blowing a dandelion; H) Running into a door; I) Running a marathon

Characteristics of Success in Physics

We present characteristics of success in physics resulting from a synthesis of the card sorting frequencies along with the labels and descriptions of the categories generated by participants. These findings include a conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY and the salient features of the conceptual metaphor: satisfaction, struggles, hope, and recognition. We incorporate participants' words and relevant *a priori* codes to elaborate on the characteristics. A modified version of the notation system used by de Guerrero and Villamil (2002) is used to keep track of language being referenced throughout the analysis with the participants' input:

CAPITALS	Denote conceptual metaphors
bold italics	Indicate the metaphor being referenced
'single quotations'	Enclose participant excerpts from the initial interview
"underlined double quotes"	Enclose participant excerpts throughout the analysis

SUCCESS IN PHYSICS IS A JOURNEY: a conceptual metaphor

Ten of the labels assigned to categories addressed similarities in the source domains which are related to conceptual metaphors. Labels resembling conceptual metaphors included SPORTS, PERFORMANCES, PROJECTS, MARATHONS, and JOURNEYS. Visualizing the frequency of participant category labels with the word cloud presented in figure 2 (Saldaña, 2013), we can see the most common category label "process," represented by the large font size, followed by the labels "journey," "positive," "negative," and "time." Considering the "process," "positive,"

and “negative” labels are likely introduced during the co-coding we can identify the conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY.

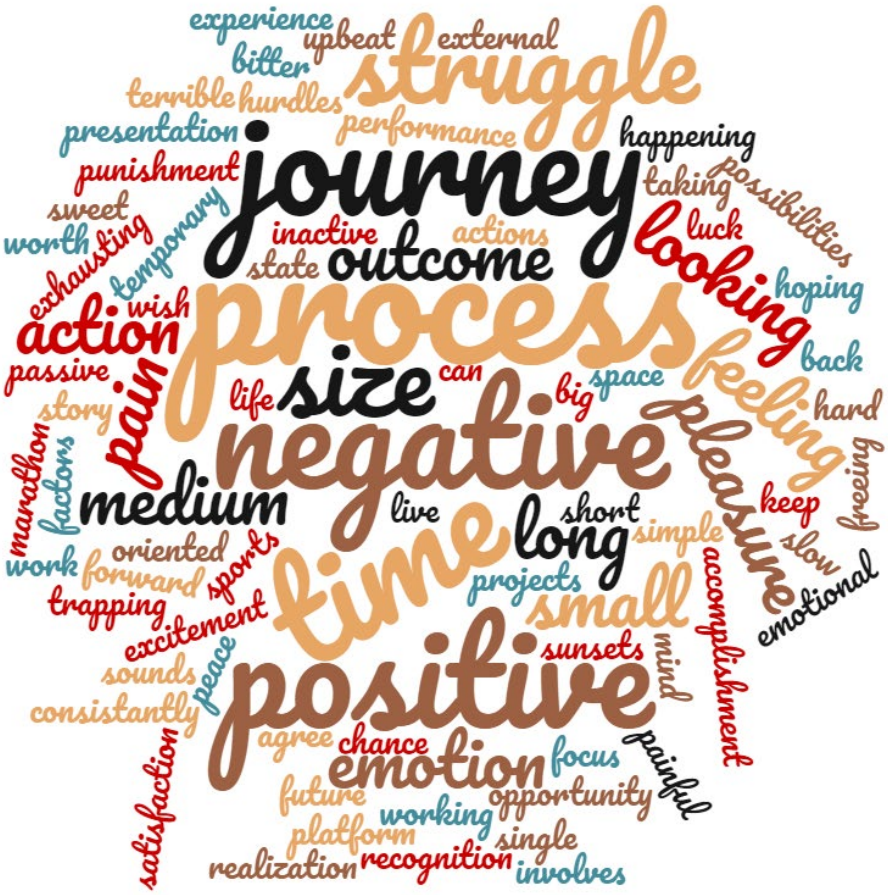

Figure 2: Word cloud visualization of participant category labels

In addition to the frequency of labels, we recognize the concept of a journey encompasses different elements captured across the metaphors, as Amazonia explained in an analogy of a soldier’s journey and its semblance to the participant metaphors:

"[The metaphors] have an overarching theme, which would be that it's not an easy field to be in. There's always gonna be a struggle before you get to this victory. But within all of these [metaphors], it's definitely, you could say, the strongest soldiers survive. Because ***running a marathon***, there's people that give up halfway. This person's ***running into a door*** and doesn't necessarily know what the outcome will be, but they're not stopping. This person's ***dragging a pail to get water from a well***. They could've given up. ***Winning the lottery***, you could've given up.

So, it's like the overarching feeling in a lot of them is there's gonna be a struggle but you can't give up. And then the benefits of getting past the struggle is rewarding. You get this adrenaline rush from ***jumping out of the airplane***, hopefully with a parachute, hopefully with a parachute. And like realizing all the pieces 'fit.' Like this person said, come to some type of 'organization.' A lot of people like physics [in general] then eventually find their niche like, 'Oh, I like physics education, I like astronomy', so that's when you get ***your clean desk***, you organize it to your liking. It's still physics, but it's specifically what you like in physics. You can ***be the great actor***. You represent that particular part of physics."

Amazonia's description of participants being at different places and the way she relates the metaphors to the journey of a soldier validates our choice to identify SUCCESS IN PHYSICS IS A JOURNEY as a relevant conceptual metaphor. In the following section we describe four relevant features of success in physics represented in this conceptual metaphor.

Features of SUCCESS IN PHYSICS IS A JOURNEY

Features of SUCCESS IN PHYSICS IS A JOURNEY were developed by identifying the most common pairs and triads from the card sorting and comparing the labels and descriptions of the categories. This synthesis of the metaphor groups and their meaning resulted in four relevant features of success in physics; satisfaction, struggles, hope, and recognition. These features are described in detail in the following subsections and are supported by a participant's visual representation of SUCCESS IN PHYSICS IS A JOURNEY.

Satisfaction

The feature of satisfaction describes the positive feelings that a person experiences from the processes and products along their journey. These relationships were informed by the second most common triad ***Having a clean desk, Exhilaration of jumping out of a plane***, and ***Blowing a dandelion.***

Satisfaction arises from both processes and products such as in the metaphor of ***Exhilaration of jumping out a plane*** where Citlali emphasizes the rush from things going right and getting positive results. The emphasis of ***Having a clean desk*** is also the satisfaction from the product of a clean desk (understanding problem components). Amy's metaphor of ***Blowing a dandelion***, was unlike the others since there was no explicit mention of an emotional response to a product, just descriptions of the process; however, there is an implied emotion inscribed in her metaphor. The way Citlali describes it, "rather than itself being an emotion, it's the emotion that it evokes in me, when I think of blowing a dandelion and when I think of my ideas breathing out and going into the Universe. It causes emotion in me." This implied satisfaction is likely the reason the metaphor was never grouped with ***Running into a door*** or ***Getting water from a well***.

This satisfaction experienced along the journey of success in physics makes struggling bearable. Such is the case for Lynn, whose metaphor of ***Biting into a caramel apple*** was often grouped both with the metaphors emphasizing a struggle and those emphasizing satisfaction, as well as being grouped in categories labeled "bittersweet" and "pleasure and pain." In her

metaphor, Lynn makes it explicit that although biting into physics can be messy and taste tart, 'overall, it is a very good dessert.'

Struggles

Struggles emphasize the way a person must deal with difficult processes along their journey of success in physics. This relationship is exemplified by the metaphors of ***Dragging a pail to get water from a well, Running into a door,*** and ***Running a marathon***.

The struggle highlights the processes in physics that are a part of attaining success, specifically the difficult processes that involve overcoming challenges. In the ***Dragging a pail to get water from a well*** metaphor, Samaria had to engage in the repetitive process of 'dragging a pail' to gather knowledge, represented by water. Similarly, Alberta highlighted the process of training to prepare for a marathon. Negative feelings experienced through the struggles are exemplified by the ***Running into a door*** and ***Dragging a pail to get water*** metaphors for which Renae comments that "carrying cups of water and running into a door are almost equivalent because both of them are really terrible."

Recognizing the struggles that are a part of success in physics is valuable since some of them can lead to growth, such as the training described by Alberta in ***Running a marathon***. However, these struggles can also highlight processes in which the person is not making any progress, where an advisor or professor can intervene to help, as in the case of Renae's ***Running into a door.***

Hope

The feature of hope describes how a person has a focus on a desired long-term product that, in some ways, is uncontrollable. These relationships are exemplified by the most commonly grouped pair without other metaphors: ***Winning the lottery*** and ***Blowing a dandelion.***

The desired product can be seen in Amy's metaphor of ***Blowing a dandelion*** in the way she describes the dandelion seeds '[going] out into the universe, to be explored by other people.' Even though Amy described this as a process, it was the final step of the process that is out of her control, where she he has hope that her ideas will be explored by others once she puts them out there. Similarly ***Winning the lottery*** captures the desired outcome of Amazonia attaining her degree after she has bought into graduate school; however there are certain uncontrollable circumstances that are represented by the inherent luck of winning the lottery.

Recognition

The feature of recognition describes the way other people's positive acknowledgements interact with the person going along their journey. This feature is exemplified by the metaphor ***Being an actor*** which was grouped the fewest times. The low frequency is likely due to a unique emphasis by Pluto on an alignment with what she is good at, what she enjoys, and what her audience enjoys. Citlali, who never placed the metaphor in a group, elaborates on this uniqueness and how the metaphor "doesn't relate to any of the others. [Pluto] just said that

success in physics was when her vocation was in line with what she was good at and it was about how she appeared to the world."

In her metaphor, Pluto expresses a sense of satisfaction when her work is recognized by others. As she explains, "of course there's a lot to do to get to that level [of acting] but once you're there, I want to tell everyone what I did." This recognition can come from a variety of individuals or as she explains, 'It can be like the world to me, or it can be just a small community that I interact with.' The recognition can become a source of satisfaction, as is the case for Pluto, but it can also be a necessary to make progress along the journey, which can be seen in Renae's metaphor where she describes her professor holding the door closed until they recognize her and let her through.

A Vision of Success: Visual representation of SUCCESS IN PHYSICS IS A JOURNEY

During the analysis one of the participants gave the research group a painting titled "A Vision of Success" of how she visualizes success in physics. Her painting, shown in figure 3, provides a visual representation to support and contextualize the conceptual metaphor of a journey and the four features identified above. The participant, Jennifer Larson, chose to disclose her identity to be properly credited for her contributions.

Figure 3: “A Vision of Success” by Jenny Larson. A visual representation for success in physics.

In her descriptions, Jennifer describes how she sees a series of stages that she must get through, which can be seen as the changing colors moving from left to right across the painting. These stages begin simple and enjoyable (represented in the bright yellows, blues and greens) and then become harder and more painful to overcome (represented by the blacks and red brush strokes). However, she has hope that when she emerges through the struggles she will

have opportunities to pursue her true desires (represented by a reemergence of brighter colors). Through this painting, Jenny sees that she depends on others which requires a sense of recognition from them to be supported through the stages. Recognition is not explicitly painted but we can identify the reader looking at her painting as a person recognizing her journey. Jenny's painting mirrors the findings of the journey metaphor and the features of satisfaction, struggle, hope, and recognition, and thus supports the findings and provides a visual representation of the characteristics.

Participant Experiences with Rigid Views of Success in Physics

The value of discussing multiple features of success is further emphasized by two participants experiences with a professor with very rigid views of success. Throughout the course of this study, Lynn was taking a course with a professor who continuously emphasized the hardships of being in physics. According to Lynn, the professor's emphasis on the struggle eventually affected her career choice. She explained the following:

> "Life is short, and it's important to feel needed and passionate about what you spend time doing. I thought a lot about what things made me happy, and what made me unhappy.
>
> I think I realized on my first day of [the course] this semester, when [the professor] said "Anyone who doesn't enjoy struggling with formulas and trying to figure out the math behind the physics concepts should change their major." I felt like he was speaking directly to me. I do enjoy math, and I love learning about how the universe works, but I always felt like I've struggled more than my peers in Physics. Maybe it was the Impostor Syndrome, but I also noticed that everyone around me came across as much more passionate about struggling with homework and problems than I would. Looking back, I wonder if I chose physics because I knew it would be challenging and wanted to prove I could do it. I've always enjoyed learning about biology and have loved plants my whole life, and when I wasn't sure about continuing to pursue physics I kind of gravitated to plant science."

Lynn ended up changing her major from physics to biology by the end of the semester. Similarly, Amy had an experience with the same professor that influenced her choice of categories of pleasure and pain, and eventually led her to rethink her career path as a physicist and instead pursue a career in teaching K-12 physics. Amy explained:

"[The emphasis on the pain] is absolutely not why I decided to go to school. I do not like pain or suffering. I don't want it in my life. It happens, but I'm not aiming for it. So I ended up dropping his class, because his focus was on this pain and suffering that I should be going through. And not only should I be going through it, but I should be enjoying it."

The experiences that Lynn and Amy went through are likely not unique and we are fortunate they are willing to share them with us. Their stories serve as a reminder to educators that individuals have different values that may not mirror their own.

Discussion

This collaborative metaphor analysis, guided by Feminist Standpoint Theory, highlights the different aspects of success in physics that are relevant to women in physics. We hope that presenting these metaphorical conceptualizations of success in physics causes a shift in how the physics community thinks about success in physics and ultimately leads to a shift in how the community supports women in physics to achieve success. Below we present a discussion regarding the subjective nature of success in physics, diversity of conceptualizations of success in physics, methodological conflicts between intended meanings and third-party interpretation, and conclude with limitations to the study.

Subjectivity in Physics as a Journey

The conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY is consistent with other discussions of success. For instance, , Moser (1999, 2000) identified the conceptual metaphor of SUCCESS IS A PATH as used by German-Swiss speakers. The PATH described by Moser can help us identify other properties of success in physics, such as obstacles, resembling Alberta's category of "hurdles." However, a stark contrast between success as A JOURNEY and a PATH is that a journey centers the individual who is experiencing the path. In physics, there are efforts to reconceptualize the career trajectory of women in STEM as a highways and pathways instead of a pipelines (Branch, 2016; Espinosa, 2011; Rosa & Mensah, 2016; Tajmel, 2019). Paths, along with the obstacles, describe the objects that an individual must go through; however, a recognition of the journey focuses on the way individuals go along the path and experience the myriad of satisfactions, struggles with obstacles, hope to keep them going through the path, and the recognition from others. In Jenny's painting we see a representation of her journey of success in physics and all its features, but unlike the painting that is now dry, the journey of students' success in physics is continuously being painted one interaction at a time. Thus, educators should be compelled to play their role in supporting students through their journey and mitigate the struggles as much as possible so that students are able to fulfill their hopes for success in physics.

Diversity of Conceptualizations

The metaphors that emerged from this analysis also highlight the different ways that people see success in physics at a given time. Success in physics is more than receiving a degree, passing a course, or getting favorable assessment scores. For some individuals, like Samaria and Amy, success in physics can be sharing ideas or discovering more knowledge. By not recognizing these process-oriented conceptualizations of success we are neglecting an entire group of people that value the process along the journey. Wang and Hazari (2018) have demonstrated that instances of explicit and implicit recognition promote students' physics identity. This should encourage us as educators to create opportunities for recognition to include the people who have process-oriented conceptualizations of success. For example, since Pluto's personal success involves performing for an audience, her and her advisor can discuss ways to create meaningful opportunities to present her research at conferences and such.

While some students may be enticed by the "only the strongest survive" narrative, other capable students are turned away by an overemphasis on struggle, depriving our community of the unique advances they could have achieved. Instructors and mentors should take care to present a range of perspectives. For example, Amy and Lynn's professor could have balanced his expositions about the struggling through the homework with recognition of the skills students were developing and demonstrating along the way and excitement about the insight their hard work resulted in, similarly to the "no pain, no gain" adage used in athletic training. While he may have felt he was providing students "fair warning" that the journey would be

difficult, it seems he was forgetting to emphasize why they were on the journey and where the journey could lead them.

To address personal conceptualizations of success, educators should have personal discussions regarding the meanings of success in physics. In this study we identify a conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY, yet there was evidence of other conceptualizations such as SPORTS and PROJECTS, although not enough metaphors were collected to formalize those conceptualizations. It is fair to assume that, while we explored a limited set of metaphors, others will have their varied conceptualizations of abstract concepts, such as success in physics (Lakoff & Johnson, 2003). Thus, continuing this conversation of metaphors of success in physics with elicited metaphors in different academic and research contexts would be useful to further identify conceptualizations of success in physics.

Conflict Between Intended and Interpreted Meanings

During the card sorting process, there were instances of tension between a speaker's intended meaning and the surface features of a metaphor. For example, when Amy was grouping based on duration, she mentioned, "the idea of blowing a dandelion is very short [in duration]. But if I think about the whole process of the developing the idea, I think it falls on the long side of middle [of her duration axis]. But if you want me to group by just what's in the quotes; it goes on the short side [of her duration axis]." This tension also emerges with the metaphor for ***Running a marathon***; although most participants emphasized the tediousness of training for a marathon, Alberta herself focused on the medal. This emphasis led her to group

her metaphor with those in the satisfaction relationship. She recognized a difference between the apparent meaning and the intended meaning of her metaphor when she mentioned, "objectively [***Running into a door*** and ***Running a marathon*** are] very similar." However, she decides to group her metaphor in her accomplishment group, because, as she puts it, "that's 'cause I know what I mean, right? Externally, it seems like the more work [category]. But I was like, "but success!" because I never thought I'd be able to run a marathon."

The conflict between identifying surface features of language and intended meanings is inherent in metaphor analysis (Armstrong et al., 2011), since third-party interpreters do not have access to the intended meanings of metaphors. This becomes a central issue in this study as we try to be faithful to participants intended meanings following the principles of Feminist Standpoint Theory. As in the case of Alberta's metaphor, interpreters may not be as focused on winning a marathon in comparison to the effort required, which led to Alberta's metaphor forming part of metaphors emphasizing the struggles of success in physics. However, this conflict goes beyond formal metaphor analysis and is a problem of interpretation in general (Ricoeur, 2016b). This leads to a recognition that even as people make explicit what constitutes their success, not everyone may value any potential product in the same way (e.g., a student might not value getting an 'A' on an exam to the same extent as her classmate or earning a physics degree to the same extent as her mentor). Therefore, it is crucial for researchers to maintain close contact with participants from the initial data collection all the way until the publication of research findings to ensure the accuracy of representations. Similarly, it is

valuable for educators trying to support the goals of their students to maintain personal discussions to minimize misinterpretations of the value different aspects of students' success.

Limitations

Since this study is limited by the number of participants, future work should expand the number of participants. For example, Citlali and Amazonia mentioned the possibility of participants having different perspectives based on career stage, which could be addressed by a larger sample. A larger set of participants could also help address questions regarding differences across demographic variables. We recognize the need to highlight the experiences of Women of Color, so expanding the number of participants should include more Women of Color. Women were the center of this study; however, we acknowledge the need for parallel efforts to address conceptualizations of success held by people of all genders.

In conclusion, this study provides a foundation for a procedure to identify similarities between metaphors about success in physics generated by women studying physics. The low number of metaphors collected was mitigated by increasing the amount of feedback from participants throughout the analysis. This procedure led to the identification of the conceptual metaphor of SUCCESS IN PHYSICS IS A JOURNEY which includes features of satisfactions, struggles, hope, and recognition from others along the way. Overall, this conceptual metaphor allows us to see the success of women studying physics as a complex process encompassing highly subjective experiences along their career paths. Due to the emotion inherent in the metaphorical expressions, it is useful to supplement this analysis with a study of the value of

emotions expressed in the metaphors. This study also revealed that in order to access other conceptualizations of success in physics, more metaphors should be collected, in addition to ensuring the inclusion of Latinas in future studies.

CHAPTER 3: ATTENDING TO EMOTION IN A METAPHOR WITH POETIC ANALYSIS

Introduction

This chapter is based on work published in the 2019 Physics Education Research Conference Proceedings[1]. In the previous chapter, we explored participants' metaphorical expressions for success in physics. However, some participants pointed out to the researchers that the (re)presentation of their metaphors in scientific prose was lacking the intended emotional expression. In this study, Amy Vary Schwandes, a participant, joined the research team to interpret her metaphor about blowing a dandelion following Colby & Bodily's poetic analysis to answer the research question, *What insights can we acquire about a participant's choice of metaphor for success in physics by attending to the emotions in their metaphor with a poetic analysis?*.

The metaphors collected in chapter 2 were interpreted with feedback from the participants; however, after translating the metaphors into scientific prose, there was a perceived lack of intended emotions. For example, a participant, Citlali (pseudonym), described: "[success in physics is like] the exhilaration of jumping out of an airplane." In the original

[1]Chapter based on Zamarripa Roman, B., Vary Schwandes, A., & Chini, J. J. (2019). Attending to emotion in a metaphor for success in physics with poetic analysis. Published in the 2019 Physics Education Research Conference Proceedings, 675-681, 2020, https://doi.org/10.1119/perc.2019.pr.Zamarripa_Roman, under a Creative Commons Attribution 3.0 License.

analysis, we interpreted this as “exhilaration that emerges from observing unprecedented results in a research project that you developed.” During member checking, Citlali stated:

> “I have read what you wrote several times. While it is technically accurate, it loses the flavor of excitement. Maybe that is necessary in trying to technically describe an emotion? I have tried to come up with better words, but not truly appreciating what the final product should look like, I have failed.”

Citlali’s email highlighted the need to capture her intended emotions and led us to question our approach. We use Feminist Standpoint Theory (FST), our guiding theoretical framework, to center women in order to address the structural inequalities they experience (Harding, 2007). However, if their intended emotions are not included in the scientific representations of their voices, then we fail the purpose of representing the world in relation to their interests (Anderson, 2020). Thus, not attending to emotions limits the knowledge which can arise from considering emotions in our epistemology (Hawkesworth, 1989; Jaggar, 1989).

This concern with being faithful to participants’ voices demanded us to seek novel methods of representing the participants’ intended meanings (Blakely, 2007). To capture the emotional essence of a participant’s metaphor, we follow the poetic inquiry of Colby and Bodily (2018). This consists of restructuring the transcript of a participant’s metaphor of a Dandelion into a poem, while interpreting it through the lens of Ricoeur’s hermeneutics to reach insights hidden in the contexts (Butler-Kisber, 2019; Colby & Bodily, 2018; Ricoeur, 2016a). This study also serves as an example of how poetic inquiry can be used to explore qualitative data in PER.

Methodology

Guiding Frameworks

In line with qualitative case studies in PER, we recognize that people's interpretation of their own lived realities guides their actions and that knowledge is socially constructed (Robertson et al., 2013). These tenets of social constructivism lead us to seek a deeper understanding of a single participant's perspective about success in physics (Cresswell & Poth, 2016; Denzin & Lincoln, 2017; Saldaña & Omasta, 2021). Furthermore, FST centers the interaction of power in women's lived realities by making claims that marginalized populations are positioned to have more relevant insights regarding issues concerning them, and thus research should start from their perspectives (Anderson, 2020; Harding, 2007). Centering power also demands we find ways to mitigate power imbalances between researchers and participants. Thus, the lead researcher (BZR) worked closely with a participant (AVS) to address the high inference nature of interpreting metaphors (Armstrong et al., 2011; Ricoeur, 1974). The lead researchers recognize AVS as an author in this work since she was deeply involved throughout the analysis and writing. This has been done traditionally in community-based research and other discipline-based education research studies with participants (Coughlin et al., 2017; L. R. Johnson, 2016; Koster et al., 2012; Secules et al., 2018).

In addition to concerns of misrepresenting expressed emotions, emotions are relevant in this chapter since emotions significantly influence the learning process. Psychology research has demonstrated emotions significantly affect task performance, engagement, and

achievement (Bower, 1992; Carver & Scheier, 1990; S. J. Spencer et al., 1999; Turner, 2007; Weiner, 1985). Education studies have revealed emotions such as boredom, fear, anxiety, and anger negatively impact learning gains and engagement, while emotions such as joy, happiness, and excitement positively affect interest in courses (Cooper et al., 2018; Craig et al., 2004; England et al., 2017; Pekrun et al., 2002; Schutz & DeCuir, 2002; Tomas et al., 2016). Biology education researchers have also noted that women in introductory biology were more affected by negative academic emotions that could lead them to self-deprecating cycles (Pelch, 2018). Studies in PER have revealed links between emotions of control (e.g., frustration, calmness) to performance (Bodin & Winberg, 2012); emotions towards physics topics to engagement (Alsop & Watts, 2000); stress to retention (Lehtamo et al., 2018); and emotions to shifts in reasoning (Gupta, 2014; Gupta et al., 2018). These correlations between emotions and learning highlight the value of considering emotions in PER to better understand their effect on learning.

The PER studies mentioned above attempt to capture students' emotive expressions by representing dialogue as transcripts with detailed notations of inflections and pauses as well as cartoon comics for visual aid (Gupta, 2014; Gupta et al., 2018; Jefferson, 2004). We use poetic inquiry "to evoke emotional responses that bring the readers closer to the work, and to permit silenced voices/stories to be heard" (p. 230, Butler-Kisber, 2002). More specifically, we use found poetry, which is the restructuring of texts into poems (Richardson, 2011), to "stress moments of subjective feeling and emotion in a short space" (p. 6, Faulkner, 2005). Reconstructing transcripts into new forms also leads to thinking about data in new ways,

leading to new insights (Richardson, 2011). To guide the analysis of the transcripts, we apply Ricoeur's hermeneutics as done in Colby and Bodily's poetic analysis (Colby & Bodily, 2018).

Ricoeur's (Ricoeur, 2016a) hermeneutics focus on a process of interpreting texts. Ricoeur recognizes text is "someone saying something to someone about something." Since text becomes distanced from its intended meaning when an author is not present to explain, the distanced text (the something being said) is primarily understood in terms of the worlds of new interpreters. This naïve understanding demands consideration of the dialogue's original contexts (who said something and to whom was it said) for a deeper understanding of the author's intended meaning (the "about something"). Once this deeper meaning is attained, it can then be inspected to reach deeper understandings of interpreters and their worlds influencing their interpretation, what Ricoeur calls appropriation (Colby & Bodily, 2018; Geanellos, 2000; Ricoeur, 2016a; Tan et al., 2009). The process of interpretation is central to analyzing metaphors, which often lack explicit explanation, and thus it is appropriate to implement Colby and Bodily's hermeneutic poetic analysis (Colby & Bodily, 2018; Ricoeur, 2016a).

Data Collection

In the original study, eleven participants were recruited via email sent to the researchers' department to participate in a study regarding women's perspectives of success in physics. Metaphors were elicited during an hour-long semi-structured interview (Saldaña & Omasta, 2021) conducted by BZR with a prompt to complete the sentence "success in physics is

like…" with a metaphor. Individual follow-up meetings were scheduled two months after the interview, where participants explained and coded their metaphors with BZR to develop initial interpretations, as detailed in in chapter 2.

For this proof-of-concept study, we focus on AVS's metaphor. BZR felt the first interpretation of AVS's metaphor lacked the emotions AVS had expressed during the interview. AVS had also expressed desire to contribute to the project and was available for a prolonged analysis. Unfortunately, Citlali (whose response was used in the introduction) was unavailable for co-analysis.

Positionality

We recognize that power differentials exist between the main researchers (BZR and AVS) due to their backgrounds, such as BZR's status as a man doing research centered on women, which likely provides him privileges in academia.

BZR is a man who comes from a Mexican Puerto Rican background. His education background is in physics, and he is a graduate student who has been enrolled in school full time since the beginning of his education.

AVS is a white woman who received a degree in economics, taught high school chemistry for several years, then returned to college to pursue a degree in physics for her personal benefit. At the time of this study, AVS is teaching high school physics, while still being enrolled in physics courses. However, she is not pursuing a degree in physics.

To mitigate some of the salient power imbalances, both researchers maintained open communication with regards to each other's privileges and decided to meet at AVS's preferred location to shift power to her and prioritize her comfort.

Methods

This poetic analysis consists of three steps: (1) presenting the original text and explaining what is said in it; (2) reading behind the text, consisting of explicating the original context of what was said and reshaping the text to develop a deeper understanding; and (3) reading in front of the text, consisting of constructing a poem which captures the essence of the intended meaning, opening the text and poem to possible interpretations, and considering our worlds that led to our interpretations (Colby & Bodily, 2018). For the analysis, BZR and AVS met for four one-hour-long weekly meetings at AVS's home nearly a year after the initial interview. Distance from the initial dialogue and text is needed for interpretation, yet time may introduce memory bias. Since BZR and AVS are the closest people to the original context, their interpretations, however biased, remain relevant. Future analysis would be conducted within a year after interviews to distance the text and minimize bias. The meetings were recorded and transcribed to refer to the analysis.

Analysis

(Re)presenting the Transcript

The first step of the poetic analysis is to represent the original text and explain what is being said to achieve a surface understanding of the expression's content. This step is what was done in our initial interpretations of the metaphors and is what Tan et al, (2009) call a "naïve understanding" since it does not consider the context that motivated the expression. The transcript follows typical punctuation agreed upon during the follow up meeting.

"BZR: So success in physics is like…
AVS: Hm. Um. You know that plant? It's a weed. I think it's a dandelion. The one that grows in with a puff ball? And then you blow on it and make a wish? That's success in physics.
BZR: How so?
AVS: Um. Because it starts with just this little idea. And then it grows into these possibilities. And all you have to do is breathe and then they go into the universe. To be explored by other people. And that's success in physics."

The following explanation was developed after the initial follow-up meeting where AVS explained the metaphor:

"Success in physics is developing ideas about the universe, discussing the ideas, and sharing those ideas to further be developed by the community and the general public."

This naïve understanding made explicit the content of the metaphor, which highlights the value of developing ideas about physics with other physicists; however, BZR and AVS noticed it minimized the emotions AVS had expressed. During the poetic analysis meeting we explored the reasons for the lack of emotions and realized that BZR felt a scientific demand to leave out the implied emotions. In the following subsection we proceed with the poetic analysis

to expand the naïve understanding by reading behind the text and recognizing the context of the original expression.

Reading Behind the Text

In this section we proceed to read behind the text (Ricoeur, 2016a) by making explicit the original contexts of who said the metaphor and to whom it was said. BZR and AVS reviewed the transcript and audio of the initial interview to make explicit the intentions of AVS and the cultural and sociological context of the dialogue. Afterwards they proceeded to discuss the meaning of the metaphor. This discussion was recorded and transcribed, then reviewed in a later meeting to ensure agreement. This discussion informed the analysis of the restructured transcript.

AVS and BZR focused on the pauses and emphasized words in the original recording to explore the meaning behind them. Timing the pauses slowed down the analysis to elaborate on their purpose. This led to the following transcript with timed pauses, elevated volume in ALL CAPS, and a higher pitch in *italics*:

> "BZR: So success in physics is like…
> AVS: Hm. [3.744s] Um. [2.464s] You know that plant? It's a weed. I think it's a dandelion. [0.409s] The one that grows in with a puff ball? And then you blow on it and make a wish? [1.107s] THAT'S success in physics.
> BZR: How so?
> AVS: Um. Because it starts with JUST [0.235s] this LITTLE idea [.866s] and then [0.534s] it GROWS into these POSSIBILITIES [1.025s] and all you have to do is *BREATHE* and then they GO [0.781s] into the UNIVERSE [0.503s] to be EXPLORED BY OTHER PEOPLE. [1.137s] And THAT'S [0.323s] *success in physics*."

The metaphor began with large pauses and AVS identifying the plant as a weed. AVS explains how there were many thoughts on her mind about classes, research, and her personal life, which made it hard to remember the name of the plant. She clarifies that the pause after "make a wish" was not to emphasize the wish, but to provide time for a response. AVS mentions it is important to minimize the importance of the "wish" because, as she explains, wishing is not real unless there is a plan.

AVS explains that the pauses leading to "possibilities" served as emphasis to the words and provided time to digest the emotions she wanted to elicit, reflecting her training as a teacher to provide processing time. The pause after "possibilities" served as a stopping point and a transition. Those emphases culminated at "breathe," which was said with a strong softness as if AVS was releasing pressure.

The "breathe" was quickly followed by "then they go," where "go" was the most vocally emphasized word of the metaphor. Attention was then drawn to "the universe," which was followed by a reflective pause that then concluded with "to be explored by other people." The final "success in physics" was then emphasized similar to the "breathe" expression.

The transcript is then reconstructed to emphasize the intended expressions and elaborate on their meaning. This consisted of removing the first portion of the dialogue that only served the purpose of identifying the plant and using the pauses as line breaks to slow down the reading:

> "Because it starts with JUST
> this LITTLE idea
> And then it GROWS
> into these POSSIBILITIES.
> And all you have to do is *BREATHE*

and then they *GO*
into the UNIVERSE
To be EXPLORED BY OTHER PEOPLE
And THAT'S
success in physics"

AVS explains that "just" and "little" served to emphasize that an idea does not have to begin as a grand idea. "Grows" was emphasized to reflect the process needed to make wishes happen, which coincides with mentions in the interview of her passion for sharing her ideas of quantum mechanics with physicists and conducting research as a plan to grow them.

AVS explains how "possibilities" was important in eliciting emotions of hope. At the time of the interview, she was in therapy to process overwhelming situations in her life. She was dealing with a professor who overly stressed the difficulty associated with studying physics and she was unmotivated by research since she felt her advisor was more interested in conversations about physical phenomenon than the social benefits of physics. This compelled AVS to share a "naïve hopefulness," as she put it, to inspire others who are overwhelmed by negative messages to dream big.

AVS explains the "breathe" as the personal action that must be implemented to materialize the possibilities. "Go" was heavily emphasized to highlight the external, uncontrollable aspects of the process. This reflected the uncontrollability of others thinking about her ideas and hoping for positive results from computer analysis performed in her research at the time.

Her results and ideas would then be the seeds that go out to the emphasized "universe." In this context, AVS wanted her ideas and results to go out into the field of physics.

AVS had a desire to have her ideas not only get passed down to others, such as students, but passed up to other researchers to question and theorize on.

Reading in Front of the Text

In this section we read in front of the text by focusing on the intended meaning of the metaphor and opening the text to the possible ways it could be interpreted by others (Colby & Bodily, 2018; Ricoeur, 2016a). To do so, the metaphor was decontextualized from physics and reconstructed by AVS into the found poem in figure 4. Then we explored how the meaning was appropriated by the researchers.

Figure 4: “Dandelion” by Amy Vary Schwandes. A found poem.

In the poem, AVS highlights the meaning of the metaphor with formatted text positioned in intentional places. The poem begins with “just” at the top highlighting that an idea can start small, which is further emphasized by “little.” The line spacing before “grows” depicts the next step and is shifted left to signal the start of a process. It is met with “into these

possibilities" shifted right to mark the next step. The "possibilities" is a bigger text to indicate the growth that is needed, which leads to "Breathe" after a line break. This "Breathe" is capitalized to indicate importance of the action and is a softer shade as a relaxation. After a large line break is "GO!" indicating the leap of faith that is necessary to let uncontrollable processes take their own course. AVS emphasized the importance of this with the large size and capitalization of the word. The "Universe" is then the destination of the ideas, followed by a large line break before "explored by other people," depicting it as the ultimate goal.

Now we turn to exploring possible interpretations of the metaphor by a broader audience. We agreed that AVS' metaphor can be applied in a myriad of contexts since ideas are developed in all aspects of life. This generalizability of her metaphor can serve as a source of hope for others looking to develop their ideas, regardless of context.

The next step in the analysis is to explore our appropriations of the metaphor meaning (i.e. the way we make the meaning our own) (Ricoeur, 2016a). In exploring our appropriations of the meaning, we saw that the metaphor can be applied to the development of this project itself. AVS decided to no longer pursue a degree in physics because she recognized a misalignment with her personal values of service and a life without constant negative messaging. However, by discussing her idea of success in physics, BZR and AVS developed that idea and grew it into possibilities that manifested and turned into this chapter, along with a published conference paper (Zamarripa Roman et al., 2020) and an associated poster. Together they have taken this idea of success and have put it out into the Universe of PER where it can be explored by other experts in the field. AVS has experienced success through this project and

plans to continue as she is transitioning into becoming a physics education researcher. AVS has also become committed to looking for other communities devoted to service and is actively looking for a spiritual community with similar values as her own.

The reconstruction into a poem led BZR to new insights with regards to limiting participant expressions when he thought the poem took up too much empty space for the four-page limit of the conference paper (Zamarripa Roman et al., 2020). BZR suggested to make the poem smaller; however, AVS quickly responded that the large spacing was intentional. As she explains, AVS needs space to breathe, to grow, and to express herself. AVS explicitly mentioned how meeting in her home allowed her the freedom to express herself comfortably. She also referenced that she prefers to take up space on large tables while studying and tends to ask for extra scratch paper during tests to have more space for notes. Taking it a step further, AVS expressed her need for space to live a balanced life where she can hold on to her values, which is one of the reasons she chose to not continue pursuing a physics degree. This interaction surrounding the initial request to minimize AVS's found poem, thus led the research team to recognize that participants need space to express themselves in collaborations, as well as to recognize the value of providing students space in different educational contexts to support their learning.

Discussion

This poetic analysis was inspired by a need to represent the emotions captured in AVS' metaphor of success in physics as a Dandelion. The analysis allowed the researchers to reveal

insights about what AVS initially meant to get across in her metaphor, why she chose not to get a physics degree, and ways in which she is still successful in physics. During the analysis, AVS made it clear that she chose to portray a very positive perspective of success in physics to inspire students whose professors constantly emphasize the struggles in physics or whose advisors are less focused on the social aspects of physics. AVS wanted to do the work of highlighting the beauty of physics to inspire future physicists, however that should not be a student's responsibility. As educators, we can and should be "making physics connect" (Campbell, 2016) to the communal goals possible with a physics career, which has been demonstrated to facilitate interest in STEM (Diekman et al., 2011).

Reconstructing the transcript into a poem also revealed the value of providing space to participants: providing space in time to answer and explain difficult questions (Brayda & Boyce, 2014), physical space by interviewing in spaces where they feel comfortable (Herzog, 2005, 2012), space in writing to express themselves in their words (Manning, 2018), space to theorize on their own perspectives to support their agency (hooks, 1991, 1994), and space in authorship to give credit for their work (Sinha & Back, 2014). Thus, poetic analysis can be valuable to researchers intending to analyze and represent emotional interview data in ways that lead to fresh insights and amplify marginalized voices.

The overarching study on success in physics could benefit from applying this analysis to all participant interviews. However, we recognize this demands additional effort from participants and the increased time lapse may introduce greater biases. Thus, future studies

should be designed with poetic analysis in mind to prepare participants and minimize the time between interviews and analysis.

CHAPTER 4: LATINA'S METAPHORICAL CONCEPTUALIZATIONS

Introduction

There is an ongoing need to address the gendered, racialized, and intersectional experiences of success of Women of Color as they remain severely underrepresented in physics (Ong, 2005; Ong et al., 2011; Porter & Ivie, 2019; A. L. Traxler et al., 2016). The systems of power and privilege in the academic fields of science, technology, engineering, and mathematics are complex and often privilege the perspectives of success associated with white men, resulting in the marginalization of values held by people who are non-white and/or not men (A. Johnson et al., 2011). However, we can disrupt these systems by focusing on the experiences of those at the intersections of these dimensions of identity.

Past studies have explored gender in physics, including journal issues dedicated to the topic (Brewe & Sawtelle, 2016; Cochran & White, 2020), as well as work about race in physics (Cochran & White, 2017; The AIP National Task Force to Elevate African American Representation in Undergraduate Physics & Astronomy (TEAM-UP), 2020); however, literature about Women of Color in physics is scarce (A. Johnson et al., 2011, 2017; Ong, 2005; Rosa & Mensah, 2016), especially literature specifically about Latinas in physics compared to other STEM disciplines (Arroyo, 2017; Banda & Flowers, 2018; Del Carmen Bello, 2018; Leyva, 2016; Nubia-Feliciano, 2016; Ruiz, 2013).

In past work we investigated conceptualizations of success in physics held by women at a single institution; the participant sample in that study consisted of nine participants, none of

whom identified as Hispanic or Latina. As we recognized that the experiences of people at these intersections of identity varies widely with regards to the discrimination and oppression that they may experience, it is crucial that we attend to these further underrepresented perspectives. In addition to the underrepresentation of Latinas in our past work, it is important to recognize that Latinas are one of the fastest growing populations in physics, reflected by the number of Bachelor's degrees earned by Latinas tripling over the last 20 years (Porter & Ivie, 2019). Nonetheless, Latinas are still an underrepresented group in physics; the actual number of bachelor's degrees awarded to Hispanic women was slightly over 100 in 2016 (Porter & Ivie, 2019). These trends in the growth of Latinas in physics compels us to investigate the views of success of this group whose perspectives are still underrepresented and quickly becoming a significant portion of those studying physics.

In past work, the low number of metaphors collected made it difficult to carry out a more traditional metaphor analysis of the conceptual metaphors underlying participants' expressions. To address these concerns, we will seek to answer a similar question as in chapter 2; however, this study will only focus on perspectives held by Latinas and seek to collect a larger number of metaphors to conduct the analysis. This leads to our research question: *What are common conceptualizations of success in physics identified across explicit metaphors shared by Latinas studying physics?*

Methodology

Guiding Frameworks

This study is guided by the philosophical assumptions stated in chapter 1 and the frameworks of Feminist Standpoint Theory (Harding, 2007), conceptual metaphor theory (Lakoff & Johnson, 2003), gender performativity (Butler, 2011), and intersectionality (Crenshaw, 1991) as described in the sections above. In addition to these frameworks, the explicit focus on Latinas' perspective lead us to incorporate an additional guiding framework of Critical Race Nepantlera Methodologies (Acevedo-Gil, 2019).

Critical Race Nepantlera Methodologies

Our philosophical assumptions, the explicit focus on Latinas, and the lead researcher's experience as a Latino in physics lead us to Critical Race Nepantlera Methodologies (CRNM) as a guiding framework to generate knowledge in a critical, supportive, and respectful manner (Acevedo-Gil, 2019). CRNM incorporates tenets of Critical Race Theory as used in education, namely the recognition that racism is pervasive, dominant narratives should be challenged, researchers have a commitment to social justice, the experiences of People of Color are to be respected, and the research process should entail interdisciplinary methods (Crenshaw, 1989; Solórzano, 1998). CRNM incorporates the concept of Nepantla by recognizing researchers as in-between multiple worlds and as bridge builders to connect the worlds (Anzaldúa, 2015). The concept of Nepantla is connected to Chicana Feminist Epistemology, which recognizes multiple aspects of cultural intuition, such as the value of the experiential knowledge of Scholars of

Color that supports data analysis, knowledge of existing literature, professional knowledge of a particular discipline, and a commitment to include participants throughout the process of data analysis (Calderón et al., 2012; Delgado Bernal, 1998).

Critical Race Nepantlera Methodologies guides our study design in multiple ways. Recognizing the racial and gender disparities in academia leads us to focus on Latina's experiences. Our commitment to social justice also pushes us to include mechanisms to empower participants in the study design. For us, that meant ensuring that participants are financially compensated for their contributions, as well as providing academic resources that could benefit them. The lead researcher's experiences with and knowledge of the supports available for Latinx physics students allowed him to suggest resources that are relevant to individual participants.

Participants

We recruited participants who self-identified as Hispanic women pursuing a degree in physics at four-year universities in the United States. However we shifted discourse towards the use of 'Latinas' since the term 'Hispanic' has a history of being used to "other" people with Spanish-speaking origins, while 'Latina' was developed as an empowering term to unify people with Latin American origins living in the United States (Alcoff, 2005). Participants were recruited via an email sent out to physics departments with high enrollment of Hispanic women and physics degrees awarded, as well as sent by the National Society of Hispanic Physicists to their student members. Email recipients were asked to share the recruitment with other potential

participants in their personal networks as a form of snowball sampling. The recruitment period happened from October to December 2019, which is during typical fall semesters.

Our final sample consisted of 20 participants at different stages of getting a physics degree from a wide range of U.S. institutions encompassing a diverse set of backgrounds. To avoid the participants being identified through the disclosure of too many demographic identifiers, we present general descriptions of the whole participant sample. The participants consisted of 12 students pursuing a bachelor's, two master's students, four PhD students, one person transitioning into her bachelor's and one student transitioning into her PhD studies. All the participants who chose to provide information regarding race and ethnicity identified as Hispanic or Latina, with three of them also identifying as white, one as Native American, and one as Chicana. More detailed descriptions of the Latinx background included relations to Brazil, Colombia, Cuba, Dominican Republic, Ecuador, Honduras, Mexico, Paraguay, and Puerto Rico. When asked about their gender identity, most participants identified as a combination of female or woman, and one participant identified as non-binary. Each participant was asked to provide a pseudonym, and the researcher suggested they choose a familiar name, like a relative's name; this practice avoids the risk that pseudonyms chosen by the researchers which may lose cultural relevance to participants' lives. In table 4 we present participants' chosen pseudonyms in alphabetical order along with information regarding their intended degrees and the location where they are studying as a proxy of their college for the purpose of anonymity. It is worth noting that Monica and Nandy were living in their respective locations while they transitioned into their next academic stage.

Table 4: Participant pseudonyms and information regarding studies

Pseudonym	Location Of Studies	Intended Degree	Discipline
Ale	Utah	BS	Physics/Astronomy
Arienette	Arizona	BS	Physics
Connie	California	BS	Applied Physics
Edith	Texas	MS	Physics
Francesca	Florida	BS	Engineering Physics
Helen	Utah	BS	Physics/Astronomy
Isabel	California	BS	Applied Physics/Math
Luna	Texas	PhD	Physics/Astronomy
Melissa	Texas	MS	Physics
MJ	California	BS	Physics/Human Development
Monica	California	AS-BS	Physics/Astronomy
Nandy	Maryland	BS-PhD	Planetary Science
Natasha	Michigan	PhD	Physics
Nicky	Florida	BS	Physics
Pink	California	BS	Physics
Rachel	Florida	BS	Health Physics
Rafaela	Michigan	PhD	Physics
Redlush	New York	BS	Physics
Selena	Florida	PhD	Planetary Physics
Virginia	California	BS	Astronomy

Data Collection

In line with our guiding frameworks of Feminist Standpoint Theory and Critical Race Nepantlera Methodologies, our data collection consisted of interviews following a semi-structured protocol to capture the rich descriptions of participants' perspectives about success and physics. The interviews took place shortly after participants were individually recruited. Each interview consisted of up to one hour of participants answering the questions in our

interview protocol with any remaining time of the hour dedicated to providing participants with relevant information to support their trajectories in physics, in line with our commitment to support the well-being of participants (Acevedo-Gil, 2019). The interview protocol, shown in full in Appendix E, consisted of questions about success in general, success in physics, specific aspects of the participant's journey in physics, and a section discussing their perception of others' views of their success in physics. After collecting responses to the questions, participants were informed about conferences such as the APS Bridge Program Conference, the National Mentoring Community Conference, and the conference for the Society for the Advancement of Chicanos/Hispanics and Native American scientists (SACNAS), as well as information on how to secure funds to attend the conferences. Students interested in graduate school were also informed about graduate school application waivers and alternative ways of applying to graduate school through programs such as the APS Bridge Program.

This study reviews responses to the prompt "Complete the thought with a metaphor or analogy 'success in physics is like…'" This prompt was asked early in the interview to minimize the metaphorical language used by the interviewer biasing participants' metaphorical expressions. In total we collected 21 metaphors of success in physics, one from each participant plus an additional metaphor provided by one of the participants.

Analysis

The analysis for this study followed traditional approaches to metaphor analysis where researchers review collected metaphorical expressions and compare them with each other to

identify overarching conceptual metaphors that can provide insights into the abstract structure of the concept in question (de Guerrero & Villamil, 2002; Palic Sadoglu & Uzun, 2014; Paulson & Armstrong, 2011).

To begin the comparison of metaphors, we first had to establish interpretations for the metaphors. Interpretation of metaphors consisted of reviewing the complete responses to the prompt, paraphrasing the metaphor in terms of the source domain, writing out the interpretations as seen by the lead researcher, writing out the reasons for the chosen interpretations as well as any doubts that might still be lingering, and finally peer debriefing with a colleague with expertise in qualitative research in physics education as well as lived experiences as a Latina until agreement was achieved. This procedure allows us to establish a certain level of rigor to validate and increase the trustworthiness of the interpretations from the lens of the researcher and people external to the study (Cresswell & Miller, 2000). To establish trustworthiness from the lens of readers regarding researcher interpretations, an example of the notes generated throughout this process is included in Appendix F. Ideally the interpretations would be supported from the lens of participants through their member-checking as was done in chapter 2; however due to COVID-19 it became increasingly difficult to reach out to individual participants and request their labor for the sake of the study.

To identify relevant conceptual metaphors, the paraphrased metaphors were compared to each other with regards to similarities in the source domains and separately with regards to similarities in target domains. The identification of similarities in target domains is done to maintain focus on the intended meaning of participants, while the identification of similarities

in source domains provides the basis of common conceptual metaphors used to structure the target domain of success in physics. To validate and increase the trustworthiness of the identified themes (Cresswell & Miller, 2000), the lead researcher collaborated extensively throughout the metaphor analysis with the same expert above to mitigate significant misappropriations of the metaphors. Additionally, the two researchers generated their own themes with regards to source and target domains and debriefed until agreement was reached for the final themes presented in the following section.

Findings

In this section we present the metaphors collected and the relevant conceptual metaphors identified across the metaphorical expressions.

Participant Metaphors

In total, 21 metaphors were gathered and interpreted by the researchers through the process outlined above. In table 5, we present the source domain of participants' metaphors and a short excerpt elaborating on the metaphor in participants' words. Interpretations established by the researchers with longer excerpts are presented in Appendix F.

Table 5: Participant metaphors with identified source domain and short excerpts.

Participant	**Source domain** Success in physics like…	**Short excerpt**
Ale	the ugly duckling	because you have everything turned against you, nobody really thinks you'll make it.
Arienette	a tree growing	It has to get down into the depths of the ground before it can shoot up into success and bear fruit

Participant	Source domain Success in physics like…	Short excerpt
Connie	learning/teaching how to ride a bike	once you have learned to ride with training wheels, then you can get off the training wheels and you can go for longer rides
Edith	a rocket taking off	You have to really like escape whatever is pulling you down, but then once you cross that threshold you're just flying
Francesca	putting a puzzle together	but the puzzle is just a white piece of paper or like a white square. So you have to figure out what it's supposed to be.
Helen	running a marathon	cause it's a very long process and you have to really love it in order to stay in the race
Isabel	an oversaturated sponge	Like there's so much that we're learning. It's sometimes so much.
Luna	solving a puzzle	a very complex puzzle that not all the pieces are there. There's sub pieces to the pieces, with each piece would be like each sub field
Melissa	climbing a really tall mountain	and then when you finally get to the top and you can finally take a breath and relax
MJ	energy	when I'm doing physics, when I'm in physics class, when I'm just doing something relating to it in general, it energizes me.
Monica	a balance	like weights on one side and the other, kind of like trying to figure out where working everything is being in equilibrium
Nandy	stargazing	stargazing at night with no troubles in the world. Being able to just think about and understand and be able to live the moment
Nandy	being on the beach	like being able to enjoy the waves and the environment, but also as a physicist, I'm able to think about the physics of it
Natasha	wearing and owning glasses	One thing is for people to recognize you that you have physics glasses on… [and] you allow yourself to think, “I'm actually a physicist”
Nicky	being the first to the moon	it's a race to succeed. But it's also a race to expand the knowledge and to make an impact
Pink	building a puzzle	at a lower level, like intro stuff, it’s like building a puzzle. You know, you just put it together.
Rachel	a roller coaster	I see my professor and think they are kind of successful because they're doing what they like and they have to put a lot of work into it
Rafaela	staying hydrated	you need it in your life, like in order to understand a lot of things.
Redlush	cracking open an egg	I failed so many times before cracking it open successfully
Selena	winning a basketball game	it has to be like winning. And winning that game is like publishing the paper and then getting the experience
Virginia	swimming upstream	it's possible, but it's really hard. Um, and I feel like the level of difficulty definitely varies on like who it is

Identified Conceptual Metaphors

Throughout the identification of themes across metaphors, the researchers identified similarities with regards to the source and target domains. The process of comparing themes with Rodriguez, a Latina with expertise in qualitative research, served useful since the researchers identified complementary themes, with Rodriguez identifying topics related to the target domain and perceived intentions of participants, while Zamarripa identified themes regarding source domains and the metaphorical features of the expressions. The list of initial themes is provided in Appendix G. The researchers then discussed the identified themes, with an emphasis on the source domains, until they came to agreement on the conceptual metaphors underlying the metaphorical expressions. Relevant conceptual metaphors used to describe success in physics include various aspects of NATURE (i.e., LIFE GROWING, OVERCOMING GRAVITY, A PEACEFUL SCENERY), as well PUZZLES, RIDING A VEHICLE, SPORTS, and WATER. We discuss the metaphors at length in the section below by elaborating on the metaphorical expressions and features of their target domains.

SUCCESS IN PHYSICS AS NATURE

The first conceptual metaphors we discuss are related to success in physics as nature. Participants used multiple metaphorical expressions more specifically about life growing, overcoming physical forces such as gravity, and expressions regarding a very grounding and peaceful landscape.

A GROWING ORGANISM

The conceptual metaphor of SUCCESS IN PHYSICS IS A GROWING ORGANISM is representative of metaphors such as Ale's expression of the Ugly Duckling and Arienette's tree. In both expressions there is this idea of biological life, a duck and a tree, that goes through a form of growth and change. This growth can happen with regards to one's social identity, such as the duckling becoming a beautiful swan, which was used to represent how Women of Color must overcome negative others' negative perceptions about their ability to do physics and become an inspiration to other Women of Color. The growth could also be with regards to developing an idea about physics with solid knowledge foundations to eventually become a contribution to the world, represented by Arienette in terms of a tree developing its roots and eventually growing to provide its fruit to the world.

OVERCOMING GRAVITY

A different aspect of nature that we observed is that of overcoming physical forces, more specifically that of gravity. This conceptual metaphor was seen in expressions by Edith, Melissa, and Virginia about a rocket taking off, climbing a tall mountain, and swimming upstream. Although these are not all explicitly about gravity, we see gravity as the main force used to represent the hardships working against these Latinas. Hardships include dealing with family responsibilities while attempting to dedicate time to physics, represented by the gravity pulling Edith's rocket; the effort required to establish oneself professionally, represented Melissa's implied effort required to climb upwards; as well as toxic physics environments

lacking supports, such as tutoring and one-on-one help from professors, represented by a downstream current working against Virginia.

On a similar note, Monica uses the metaphor of a balance to describe how she trying to find stability in how she handles a variety of personal and academic responsibilities. The aspect of balancing weights is inherently influenced by gravity, relating it to this conceptualization. However, unlike the participants above, Monica does not describe a forward/upward displacement. Monica is more focused on maintaining an equilibrium to avoid failing at one of her responsibilities.

A PEACEFUL LANDSCAPE

The conceptual metaphor of SUCCESS IN PHYSICS IS A PEACEFUL LANDSCAPE was prompted by Nandy's metaphors about stargazing and being on the beach watching the waves crash. Her metaphors highlighted a grounding, almost meditative state, of being at peace and in touch with nature. In a similar way, this peaceful scenery was shared by Melissa when she reaches the top of the mountain and can breathe or when Edith overcomes gravity and she can coast in the direction she desires.

SUCCESS IN PHYSICS IS A PUZZLE

One of the most prevalent conceptual metaphors was that OF SUCCESS IN PHYSICS IS A PUZZLE. This metaphor was explicitly used by Francesca, Luna and Pink. All three participants use the metaphor to describe the process of generating knowledge in physics. Francesca and

Pink both highlight the introductory aspects of physics, which Francesca describes as the easily identifiable border pieces representing the more basic physics concepts taught in introductory courses. This conceptual metaphor also incorporates the increased level of complexity when one begins to take on higher level problems that require a more nuanced understanding of individual subfields of physics. Inherent in these metaphors of a puzzle is the enjoyable, yet challenging aspects of building a puzzle.

The relevance of this conceptual metaphor is further exemplified by Arienette's unprompted use of puzzles to elaborate on her knowledge contributions when she says, "that the fruit that you bear is going to be the knowledge that you have found for physics. *It's going to be your piece of the puzzle*. It's going to be your fruit to the world."

SUCCESS IN PHYSICS IS DRINKING WATER

This conceptual metaphor of water is prompted by Isabel's metaphor regarding an over-saturated sponge and Rafaela who speaks about success in physics is like staying hydrated. In their metaphors, water represents the physics knowledge that they are learning as students. Rafaela identifies the useful nature of physics and how it is fundamental to understanding many aspects of life, which is reflected by the fundamental nature of water as a necessity for life. On the other hand, Isabel highlights the way that she is overwhelmed by the amount of knowledge that she is asked to learn in her studies. Thus, although there is this recognition of intaking water as learning, people's sentiment towards learning differ.

In a similar sense, MJ recognizes doing and learning physics as energizing. Even though MJ does not make an explicit mention to intaking any substance, the energizing aspect of the metaphor prompts a similar vitality as described by Rafaela. The feature of water is also present in Nandy's metaphor for being on the beach and Virginia's metaphor for swimming upstream; however, water in their conceptualizations represents target features beyond physics knowledge.

SUCCESS IN PHYSICS IS A SPORT

Metaphors highlighting the competitive aspects of pursuing success in physics fall within the conceptual metaphor of SUCCESS IN PHYSICS IS A SPORT. This competitiveness is explicit in Selena's metaphor of success physics is like winning a basketball game, as well as Helen's description of running a marathon. Something to consider is that although the sports may highlight competition with others, Selena is focus on winning events, while Helen is very focused on commitment and dedication one has to have in order to continue through the competition. Selena also highlights the series of events that have to be "won" through a full season of basketball, moving on to playoffs and eventually the championship. These different events represent the individual stages and tasks that someone pursuing a degree has to go through when they have to do things like finishing one physics problem or finishing the degree, which Selena describes as her championship.

The competitive features of success in physics are similarly captured in Nicky's metaphor where success in physics is like being the first to the moon. Nicky alludes to the space

race between the Soviet Union and the United States, in which the two countries' competition to win the Cold War drove innovation and culminated in both nations achieving major milestones in science, such as the first satellites, the first humans in space, and eventually the first humans on the moon. The space "race" in and of itself alludes to this conceptual metaphor of success in physics as a competitive sport.

It is worth noting that there are other metaphors that could be seen as sports, such as the Virginia's swimming and Melissa's hiking; however, we recognize these participants expressed the activities as a means to reach a destination, compared to more like leisure activities like marathons and basketball games.

SUCCESS IN PHYSICS IS RIDING VEHICLES

We also identified the use of vehicles in several of the participants' metaphors, such as Connie's metaphor for learning and teaching how to ride a bike, Rachel's roller coaster, and Edith and Nicky's rocket ships. The participants did not explicitly mention what the vehicles represent aside from Connie who mentions the bike is the physics they are learning how to use. They elaborate on how using training wheels resembles the beginning stages of learning physics, where the simplified concepts can answer more basic questions. Then as they learn higher-level physics and the classes become more difficult, the training wheels come off. When the wheels come off, Connie says they can go for longer rides, which can be seen as taking on more complex problems. Connie's expression of going for longer rides was said with a pleasant smile that expressed a foreseeable enjoyment of the direction they will take their

understanding of physics. A clear difference in Connie's bike and the rockets and roller coaster is that the latter are vehicles where you strap yourself in and get taken for a ride without control. Edith addresses this discrepancy of control when she mentions, "once you cross that threshold, you're just flying and *you're not cruising*, but you've made it." This expression of *you're not cruising* can be seen as Edith letting us know she is still in control.

Ungrouped Metaphors

After establishing the conceptual metaphors above, we were unable to categorize two metaphors: Natasha's wearing and owning glasses, and Redlush's trying to crack an egg. This is likely due to the uniqueness of the source domains in these metaphors. Natasha alludes to wearing glasses, yet no other participant made mention to attire or tools like lenses. Redlush mentions trying to crack an egg promoting a unique source domain of cooking.

This does not mean there were no similarities to other metaphors since the idea of wearing and owning physics glasses, as Natasha mentions, relates to being seen by others as a physicist and recognizing herself as a physicist. This recognition from others is very similar to the duckling in the way that they must overcome the perceptions of others. An interesting note is that Natasha was explicitly recalling a children's book titled, "Los Mundos de Catalina" by Patrick Modiano (2001, "Catherine Certitude" in English), where Catalina wears a set of glasses that allow her to see the world differently. This children's story, along with the story of the Ugly Duckling by Hans Christian Andersen (Andersen, 1843), both seem to highlight how children's stories are used to capture the idea of dealing with one's identity in social settings.

On a separate note, Redlush's metaphor of trying to crack an egg is like Connie's learning to ride a bike since both allude to a process of trial and error; however, the target domains were too distinct to be grouped together. Learning how to crack an egg seems to be referring to the source domain of cooking, yet this is not seen in the other metaphors.

Discussion

The conceptual metaphors identified in this study provide a sense of the diversity of conceptualizations of success in physics and highlight key features to consider when providing support for students. Below we discuss in detail how each conceptualization can play a role in framing relevant aspects of education. We also discuss the diversity in our student sample.

Relevant Conceptualizations of Success in Physics

Conceptualizations of building puzzles engage a constructivist approach to learning, where individuals build new knowledge from existing knowledge as opposed to simply intake new information (Cobern, 1993). Some constructivist theories center an individual's existing cognitive resources (Piaget, 1980), while others center society's influences in that knowledge construction (Vygotsky, 1962); however, they all offer a lens that center an individual's existing resources, which has led to active and effective pedagogies (Olusegun, 2015; Tynjälä, 1999). This metaphor of knowledge as puzzles takes on the metaphor of ideas as objects (Scherr & Heron, 2016) and theories as buildings (Lakoff & Johnson, 2003), and reframes the construction process as one that is challenging yet enjoyable, unlike actually putting together a physical

building that is a grueling process. This conceptual metaphor has been discussed at length by educators (Gozzi Jr., 1996) and has become the basis of puzzle-based pedagogy in STEM fields that integrate strategic and challenging elements of puzzles in the learning process (Dasgupta et al., 2013; Stetzik et al., 2015). Beginning from the conceptual metaphor of success in physics is a puzzle thus offers a simple model that can lead to reframing curriculum and the way we engage students in discussions about their learning in more challenging and enjoyable ways.

Continuing with the discussion of learning, we discuss the metaphor of success in physics as drinking water. This metaphor frames knowledge as a fundamental and valuable resource that is transported and used by an individual. This idea was incorporated by Moser (2004) in their description of a canalization system as a model for knowledge management, where information goes into the system, is held in a reservoir, and is released at a later time for use. We agree that physics knowledge is essential for understanding a wide range of physical phenomenon; however, it is crucial to recognize the limitations of thinking of knowledge as water that can be poured into students' heads. Moser (2004) recognizes this limit as a "maximum level of knowledge" which may lead to students like Isabel who feel overwhelmed when they are required to learn large amounts of information. Therefore, it would be useful to couple conceptualizations of knowledge as a fundamental resource with constructivist conceptualizations where students not only intake information but also take their time to build knowledge with the resource in less overwhelming ways.

Metaphors regarding nature are useful to capture a wide range of features of success in physics. In the life growing metaphors, we recognized elements of developing ideas and

developing identities. The metaphor used by Arianette of developing ideas like a tree growing is in line with common a conceptual metaphor of ideas as plants (Lakoff & Johnson, 2003), which further frames the development of ideas a biological process. This conceptualization is reminiscent of knowledge construction, and therefore provides an alternate frame that incorporates elements of using available resources in a social environment leading to a students' growth and growth of their ideas. Knowledge creation in this sense takes on a conceptualization which can be appealing to individuals who identify with more nurturing aspects of knowledge production.

In addition to metaphors of organisms growing, success in physics seems connected to descriptions of interactions with natural landscapes. This became apparent in Nandy's description of success in physics as stargazing due to the similarity of the metaphor with her academic pursuits in planetary sciences. On the other hand, the peaceful conceptualizations of success in physics seem to be the outcome of overcoming natural forces working against students, captured by the uphill trajectories in the conceptual metaphor of overcoming gravity. We recognize the utility of these conceptualizations of interacting with nature; however, it is important to also recognize that the natural forces holding students back may entail interactions with other individuals, such as family and physics colleagues, and not seemingly unconscious phenomenon like gravity and river streams.

The final conceptual metaphor we discuss is that of success in physics as riding vehicles due to its relevance to students' choice to pursue academic endeavors. There are ongoing attempts to reframe discussions about the trajectory of women in physics through various

academic stages as pathways as opposed to pipelines (Branch, 2016; Espinosa, 2011; Tajmel, 2019). These discussions frame women as being the ones in control of where they want to take their careers, represented by the pathways chosen, in contrast to "leaking" pipelines that lose inanimate resources due to faults in the pipes. The choice of vehicles that one chooses to ride along their pathways is therefore important, as some vehicles such as roller coasters and rockets tend to be in predetermined paths where the individual is not in control, in contrast to vehicles that afford students the agency to dictate their paths.

Diversity of Latinas in Physics

The wide variety of metaphors chosen by participating Latinas and the diversity of backgrounds in our sample reveal that a study focusing on Latinas must go beyond a general call for Latina's contributions. Our sample of 20 participants included identities relating to nine different Latin American countries and a wide range of immigrant experiences, from Latinas who were born in Latina American countries, others who were descended from immigrant parents, and some who have been a part of communities in regions predating the western expansion of the United States. Along with recognition of the diversity in Latin American origins, we must consider the intersection of race and the Latinx experience. We recognize that a study about Latinas' experiences neglecting the perspectives of Black Latinas, Asian Latinas, and other identities beyond white is incomplete. Therefore, this study serves as a starting point to bring forth the conceptualizations of success of these Latinas into discussions of success in

physics, and we hope that future studies take more explicit intersectional approaches to analysis of success.

Limitations

Along with the limitations in the recruitment of a sample representative of Latinas, this study was severely limited in establishing trustworthiness from the lens of participants. Initial intentions of including participants in the interpretations of the metaphors, as well as the identification of relevant conceptual metaphors were compromised due to the COVID-19 pandemic interfering with everyone's lives. The lead researchers suffered in their bandwidth to reach out to participants in a timely manner and chose to minimize labor from others during the social unrest prompted by the pandemic. The effects of this limitation were mitigated by staying in contact with colleagues who identify as Latinas; however, future iterations of this work should encourage the participation of individuals recruited beyond the initial data collection. In addition to COVID-19 concerns, this study did not explore the desired outcomes represented in the metaphors, leading us to explore explicit goals in the following chapter.

CHAPTER 5: EXPLICATING LATINA'S GOAL CONTENTS

Introduction

This qualitative study serves as a pilot exploration of the goals valued by Latinas in physics to contribute to the discourse around student success and studies concerning Women of Color. In chapter 4 we were able to identify a wide range of conceptualizations regarding success. One conceptualization of success in physics as a balance made an explicit mention to trying to manage a variety of responsibilities, such as an academic workload, professional service, mentoring, family responsibilities, as well as physical and mental health. This explicit mention, as well as the wide range of pursuits represented in the conceptualizations, prompted us to explore the goals valued by Latinas so that educators may effectively support goals relevant to Latinas.

The exploration of goals in education is a subset of literature dedicated to understanding and supporting the achievement motivation of students (Ames, 1992; Pintrich, 2000). We contribute to this body of knowledge by exploring the goals valued by Latinas studying physics so that the education community may direct efforts to support the attainment of goals beyond favorable grades and academic degrees. To highlight the variety of goals held by participants, we incorporate Ford and Nichols taxonomy of human goals as a conceptual framework (Ford, 1992) to answer the research question: *what goals do Latinas in physics associate with their success*?

Methodology

Conceptual Framework for Goals: Motivational Systems Theory

We chose the Ford and Nichols taxonomy of human goals outlined in Motivational System Theory (MST) to conceptualize goals and their role in achievement motivation in line with our recognition that students have complex lives and have multiple salient goals beyond the traditional academic markers of grades and degrees (Ford, 1992). MST provides a taxonomy of goals which allows us to appreciate the wide range of goals available, as well as considers that achievement is the result of an individual's motivation, skill, biological state, and the way those interact with a responsive environment. With recognition that a supportive academic environment is a key element in a student's success, the overall study aims to bring attention to the variety of goals that can be proactively supported by faculty within academic contexts.

Table 6: Ford and Nichols Taxonomy of Human Goals

Desired within-person consequences	**Desired person-environment consequences**
Affective	Self-assertive social relationship
a. entertainment b. tranquility c. happiness d. bodily sensations e. physical well-being	l. individuality m. self-determination n. superiority o. resource acquisition
Cognitive	Integrative social relationship
f. exploration g. understanding h. intellectual creativity i. positive self-evaluation	p. belonging q. social responsibility r. equity s. resource provision
Subjective organization	Task
j. unity k. transcendence	t. mastery u. task creativity v. management w. material gain x. safety

In the Ford and Nichols taxonomy, represented in table 6, goals are divided into two types: desired within-person consequences and person-environment consequences. Desired within-person consequences are composed of affective, cognitive, and subjective organization goals. Desired person-environment goals consist of self-assertive social relationship, integrative social relationship, and task goals. Each of these categories is further divided into 24 kinds of goals that are outlined in the table 6. It is worth noting that self-assertive and integrative social goals represent concerns regarding identity, control, social comparison, and social exchanges. This taxonomy is theorized to be a comprehensive representation of human goals; however, manifestations of the goals vary depending on the context, for instance, a goal of having fun with friends could relate to belonging and entertainment goal categories. Since we intend to

represent participants' goals using this taxonomy while adhering to our commitment to be faithful to participants' intended meaning (Acevedo-Gil, 2019; Harding, 2007), we found it valuable for participants to provide feedback on the accuracy of the researcher's analysis.

Participants and Data Collection

This study builds on the perspectives of success of Latinas in physics and is a complementary analysis of the interview data collected in in the Fall semester of 2020, described in chapter 4. To collect rich descriptions of goals associated with success, the lead researcher conducted 1-hour online, semi-structured interviews with each of the 20 Latinas recruited about their views on success and physics. Interview audio was recorded, automatically transcribed, and reviewed by the lead researcher. For this study we focus on responses to the prompt, "tell me what success means to you." The prompt was strategically placed as one of the first items of discussion to minimize biasing caused by the interviewer's language and to allow participants to describe the concept of success in a more general context. In total, we collected 20 responses, one for each participant recruited, which were analyzed with the procedure outlined in the following section.

Analysis

The analysis consisted of coding participants' responses, followed up with a content analysis informed by code frequencies and comparisons across participant codes to identify relevant themes. The coding process consisted of a first cycle of *in vivo* coding to capture the

essence of the goals in the language used by participants, followed by a second cycle of pattern coding (Saldaña, 2013) using the *a priori* categories outlined in the Ford and Nichols goal taxonomy (1992). Relevant *in vivo* goals were identified in expressions that could answer the theoretical questions of "what do you want?" and "what are you trying to accomplish?" (Ford, 1992). Each *in vivo* code was allowed to be represented by multiple *a priori* codes, in line with MST which recognizes an individual instance of a goal may represent a variety of goal categories (Ford, 1992).

This coding process was implemented at three different stages to ensure the codes were uniform across participant responses and representative of participants' intended meanings. The first stage took place within a couple months of the initial interview. In this stage the lead researcher worked one-on-one with six participants at different stages of their academic trajectories to increase trustworthiness from the participants' lens (Cresswell & Miller, 2000). Participants were given access to their personal interview audio, transcripts, and notes via a secure online folder. Participants were also given access to a copy of the chapter outlining the Ford and Nichols goal taxonomy as an introduction to the theory guiding the identification of goal contents. Throughout this stage, the research took notes of the decisions leading to the choice of goal categories representing the *in vivo* goals.

In the second stage of coding, the lead researcher worked with Idaykis Rodriguez, a Latina researcher with expertise in qualitative research, to code a subset of responses to inform the coding of all 20 responses in the third stage. This second stage of coding was intended to refine interpretations of the coding scheme to code consistently across participants and to

remain faithful to Latinas' perspectives. The codes were then compared across researchers and were discussed until they came to agreement on the final categories. These codes were then compared to the first stage codes to ensure researcher interpretations were still faithful to the participants' codes and to ensure that deviations from the first stage codes were deliberate.

The third stage consisted of the lead researcher coding all 20 participant responses, supported by the notes taken during the initial stages. This final coding set up the final codes that would be analyzed with regards to the frequency of codes and themes that emerged when comparing across participants. The final codes were checked one final time with Rodriguez, as well as one of the participants who contributed to the first stage of participant-informed coding.

The goal content analysis consisted primarily of identifying goal categories with a high prevalence across participants along with identifying salient patterns of goal categories by individual participants.

Findings

In this study we identified 98 individual *in vivo* goals, with each participant mentioning an average of 4.9 goals. Each *in vivo* goal was associated with an average of 1.45 goal categories outlined in the Ford and Nichols goal taxonomy. Each participant identified goals relating to 5 distinct goal categories on average, with up to 13 and 11 distinct goal categories identified in Nandy and Natasha's responses, respectively. We present the Ford and Nichols goal categories

and the number of *in vivo* goals coded in each participant's responses in table 7. The full list of *in vivo* codes and their respective goal categories are presented in Appendix H.

Some of the most frequently coded goal categories were those represented by social integrative relationship goals, specifically regarding belonging, social responsibilities, and resource provision. Additionally, we identified a high prevalence of goals relating to task mastery, positive self-evaluations, happiness, and self-determinations. It is worth noting that no goals were associated to bodily sensations, intellectual creativity, superiority, or task creativity. In addition to frequent goal categories, researchers saw evidence of goal clusters highlighted by points of tension in the coding that demanded further investigation.

Table 7: Number of in-vivo goals per participant represented by the Ford & Nichols Taxonomy of Goals.

Superordinate Goal Category	**Goal Category**	**Number of *in vivo* Goals per Participant**																			**Total**
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	
1. Affective	a. entertainment						1		2			1	1									5
	b. tranquility									2		1	2							1		6
	c. happiness					1	1		2			1	1	1		1	1					9
	d. bodily sensations																					
	e. physical well-being											1	1								1	3
2. Cognitive	f. exploration												1									1
	g. understanding								1									1				2
	h. intellectual creativity																					
	i. positive self-evaluation				2	1	1	3						1				1	1		1	11
3. Subjective organization	j. unity											1	1	1								3
	k. transcendence	1	1		1				2		1				1		1					8
4. Self-assertive social relationship	l. individuality		1		3				1				1	1								7
	m. self-determination		1				1	1					4	2								9
	n. superiority																					
	o. resource acquisition	1								2			1								1	5
5. Integrative social relationship	p. belonging	1		2					1	2		1		2	1	1	1			1		13
	q. social responsibility	1	2	2		1				3			3	1		1	1			1		16
	r. equity				2			1						2								5
	s. resource provision	1	2	3					2			1		1	3					1		14
6. Task	t. mastery		3		1		1			2	1		1	1			1		1			12
	u. task creativity																					
	v. management				2						1	2	1	1								7
	w. material gain			1						1							1			1		4
	x. safety												1			1						2

Participant key: A) Ale; B) Arienette; C) Connie; D) Edith; E) Francesca; F) Helen; G) Isabel; H) Luna; I) Melissa; J) MJ; K) Monica; L) Nandy: M) Natasha; N) Nicky; O) Pink; P) Rachel; Q) Rafaela; R) Redlush; S) Selena; T) Virginia

Standout Goal Contents

In this section we discuss relevant themes of goals outlined in Ford and Nichols' taxonomy of goals and contextualize the categories with the *in vivo* goals and language used by participants. We present goal categories outlined by Ford and Nichols (1992) with high numbers of associated *in vivo* goals, with the recognition that individual participants with high numbers of goals within a goal category will skew the total frequency of that category since each *in vivo* goal is different within participants.

Integrative social relationship goals

The most common goals identified involved integrative social relationship goals, such as belonging, social responsibility, and resource provision, with over 13 individual goals represented in each category. Belonging goals, characterized by a desire to promote the integrity of social units, included desires to be a part of a discipline, such as Luna's desire to "be a part of contributing to the greater knowledge" of astrophysics and being well respected within these disciplines; and such as Ale and Melissa's desire to be "well known" or "considered an expert." Some participants also express desires to belong to families, such as Pink, Rachel, and Selena's desires to "support a family" or have a "stable family life."

Social responsibility goals highlight a wide range of commitments to pursue goals involving expectations from and for others, from responsibilities to have stable careers, earn awards and be involved in internships, all the way to non-academic social responsibilities

including notions of “giving back” to their communities and parents. Melissa makes explicit these academic expectations when she mentions goals of “thriving in the field” and “being respected” framed as “things that everyone wants, like academic-wise.” The notion of “giving back” as a social responsibility is highlighted by Ale as she states, “as an immigrant child [success] would be like kinda giving back to my parents everything they gave to me,” as well as Connie’s description of wanting to give back in some way.

The idea of “giving back” transitions into goals regarding resource provision, including resource provisions to family and parents, as well as contributions of knowledge to academic communities, such as Connie above and Arienette who frames her goal as a reminder that “we are adding to the puzzle of life” as we leave teachings to others. Resource provisions were also seen as providing knowledge to the general public, captured in Luna’s expression of “working in outreach so I can communicate science,” as well as Nicky’s desires to mentor and motivate in her expression of wanting “to be able to share and influence others to be also motivated to be into physics and science.”

Equity goals were also observed, however not with the high frequencies seen in other integrative social relationship goals. In the section titled Evidence of Goal Clusters we focus on Natasha’s response where she expresses a distinct explicit desire for equity among other integrative social relationship goals.

Positive self-evaluation and task mastery

Goals regarding positive self-evaluations and task mastery were the next most frequent, with 11 and 12 *in vivo* goals respectively, and encompass goals dealing with the achievement of standards and the way one sees themselves as they try to achieve these standards. Task mastery goals include explicit descriptions about achieving standards and accomplishing goals, such as Arienette's desire to "accomplish a goal regardless of the obstacles," or similar expressions by Edith, MJ, Redlush and others about "reaching your own personal goals" and having the "ability to meet up or accomplish goals."

Positive self-evaluation goals, on the other hand, include goals about the way one sees themselves along the way, such as Helen's desires for "being confident in what you're doing" and Francesca's "being in a position where you feel pride in what you do." These positive self-evaluations also include recognitions of one's effort such as Virginia's description of success being like "feeling like you're doing your best" and Isabel's description of success meaning "trying your best, even if I failed."

Happiness

The last category we discuss is that of happiness, due to eight participants discussing goals related to happiness. Happiness goals were identified in participant expressions about being happy, being happy with what you do, feeling fulfilled, and even doing something that one loves. This category, although often explicitly regarding happiness, was also prompted by discussions of love and fulfillment. The researchers coded these concepts as happiness;

however, love and fulfillment are abstract concepts that likely mean different things for each person.

Self-determination

Self-determination goals were identified when contrasted to some external standard or expectation. For example, the idea of Arienette accomplishing goals is seen as task mastery but when coupled with the idea of accomplishing goals "regardless of obstacles," the task mastery engages goals of self-determination to overcome those obstacles. In a similar way, we identified goals relating to overcoming systemic boundaries, expressed by Natasha and Helen's desires of "taking criticism constructively." In addition to these goals, some participants, such as Nandy and Natasha, feel a need to pursue goals of a healthy lifestyle and a healthy environment despite external pressures to pursue other kinds of goals. We elaborate on their goals in the proceeding section since as their goals are likely part of a broader goal cluster.

Evidence for Goal Clusters

In this section we present evidence for goal clusters which the lead researcher identified due to stark differences noted while coding. Motivational Systems Theory recognizes individuals tend to be guided by a small number of highly relevant goals (Ford, 1992), which became apparent in the first round co-coding with participants. The first instance of a goal cluster was revealed in a similarity between Monica and Nandy's discussions of shifting towards affective goals and away from social responsibility goals relating to academic standards. The

second instance discussed is with regards to Natasha's goals due to a distinct prevalence of social relationship goals stemming from a desire for personal unity along with equity.

Monica & Nandy: Affective goal cluster

Monica begins by clarifying that her views of success have changed over time and the wide range of goals, represented in figure 5, that she attempts to manage which she describes in the following excerpt:

"I feel like it's definitely changed a lot the past few years. So I think success now I would say is, for me personally, having that work-life balance where I feel like I can still do my work, enjoy my work and contribute however I can. However, you still need to have that balance for yourself and also feeling fulfilled. For me, that's what is important. Feeling fulfilled and having that work life balance where I can still just cope with everything and then just do what I can. So I definitely value just having that time away from your work. To me, that's success. Like, if I'm successful, I feel like I can balance these things. So not overworking myself. It's changed a lot, but that's what I think I value now."

Monica's current emphasis is on having unity between her academic work and personal life. Aspects of the work include managing productivity and contributing resources to her community, while also doing fulfilling work. Monica also emphasizes the importance of prioritizing her tranquility and physical well-being by coping with stressors in her life, as well as having the self-determination and positive self-evaluation of being okay with what she is do. This contrast in her prioritization of goals highlights a shift towards affective goals.

During the analysis, Monica noted that there was a change in her prioritized goals since seeking therapy as a result of burning out from overcommitting herself to academic

responsibilities. Although she still recognizes the value of contributing to her community and maintaining productivity in her academic responsibilities, her engagement in therapy led her to prioritize affective goals.

Figure 5: Monica's goal categories

This shift in goals towards more affective goals is also seen in Nandy's goals, represented in figure 6, which she describes in her views of success:

"I think that a lot of success has been defined- I have defined it in my life through awards and things that I've accomplished and internships that I've accomplished. So, that's how I've been defining it for now. But I know that looks different for everyone and it's something that I would like to also redefine… I would say I would say success for me, what I'm trying to redirect myself to right now for success is that I am able to do what I love and I am able to have what they call a work life balance and take time for my mental health and have a healthy work environment. I think that would be success for me if I'm able to obtain that in the long run, be able to obtain a very healthy lifestyle rather than a rushed or very stressful lifestyle."

Nandy's emphasis on accomplishments and awards quickly shifts to a perspective of success that centers her happiness, mental health, and a stable work-life balance. Thus, both participants make explicit their self-determination and how they are shifting their priorities towards affective goals. These shifts in goals are similar in that both Monica and Nandy are incorporating what seems to be a cluster of affective goals in their priorities.

Figure 6: Nandy's goal categories

Natasha: Social integrative relationship goal cluster

Natasha's explanation of the meaning of success begins by stating a desire for a sense of unity between her personal and professional values, with equity being a central value, represented in figure 7. This emphasis on equity then leads to various other goals relating to social responsibilities, belonging, and resource provision. She expresses this in the following:

"I think success is when you mirror into your professional and personal life, your values and your morals. So, I think many people argue that they have this model of values and morals, but whether they act on them or not, it's a different task completely. So, for me, when I define success it's, 'Am I personally being the person that I hope to hold myself to certain values and morals, and professionally am I doing the same?'

To put a more explicit example, I would say I think equity is a huge part of being just human. To be the most happiest and the most productive person that you can be, you need equity, period. So, I strive to personally be inclusive of people different from my background. And professionally, I am aware that being a Latina has a lot of weight on me completing the career that I'm choosing, but while I'm at it, I'm helping people come in."

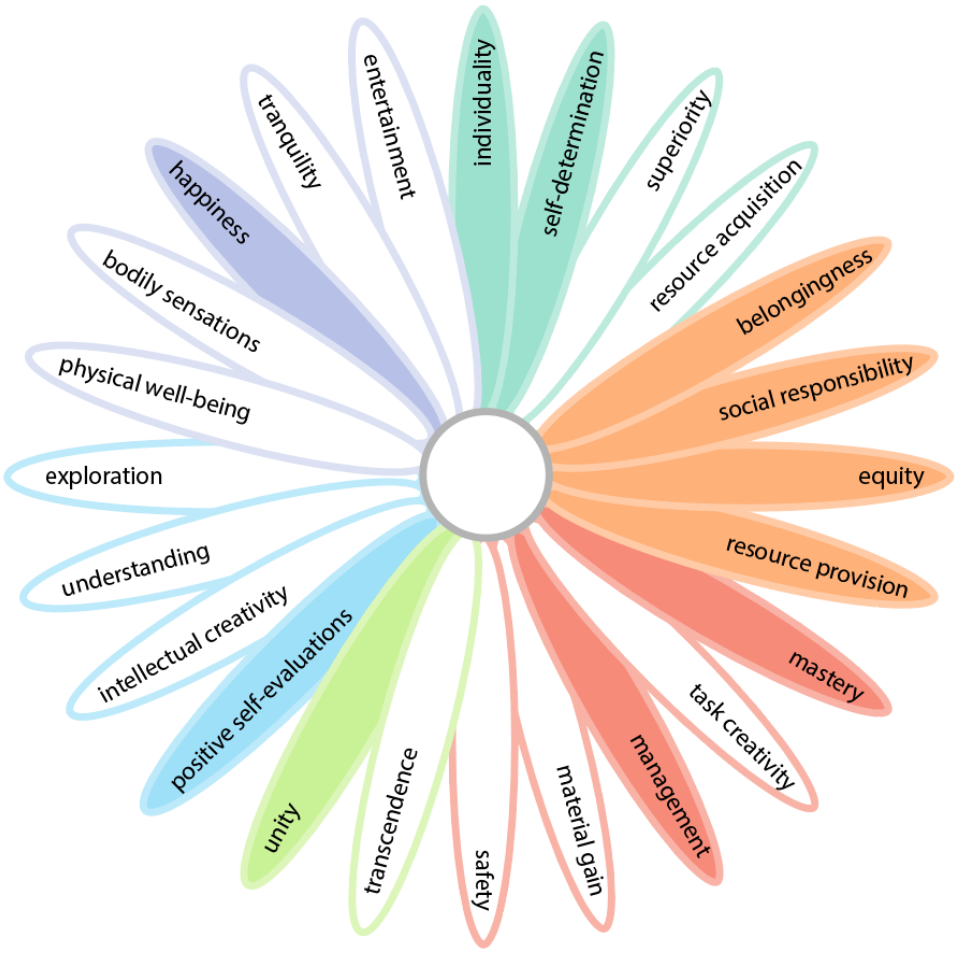

Figure 7: Natasha's goal categories

A majority of the values she highlights are representative of the different integrative social relationship goals. She explicitly mentioned equity as a necessary component to being happy and productive. Natasha then highlights her social responsibility, as a Latina, to graduate with her PhD and to be inclusive and provide support for others; especially women in physics. The last component she recognizes as a part of success is the importance of her self-determination to persist and help others belong in physics.

As we analyzed the transcript, it became apparent that Natasha has a deep commitment to her community expressed in a perceived cluster of integrative social relationship goals. This commitment to integrative social relationship goals was very distinct than other participants in our sample. It is worth noting Natasha explains in other parts of her interview that her desire for social relationship goals was shaped by past experiences with supportive professors and becoming familiar with the social disparities in physics as she practiced physics education research as an undergraduate student.

Discussion

Relevance of Identified Goals

We provide a variety of contextualized goals valuable to Latinas and discuss how they relate to the goals outlined in Motivational Systems Theory. These goals serve as an example of goals to look out for when providing support for individuals. These goals should not be considered as universal since our analysis revealed that no single goal was shared by all

participants. This is an important finding to emphasize the need for individual discussions about success in physics.

The analysis supports findings from prior studies, such as that women in STEM have a significant appreciation of communal goals (Diekman et al., 2011), reflected by a large frequency and diversity of integrative social relationship goals. Our finding should be contextualized in the recognition that participating in this study could be seen as a service to the community which would may have led to a recruited population of individuals who prioritize integrative social relationship goals.

It is important to recognize the prevalence of happiness and self-determination goals as evidence that Latinas in physics are self-determined individuals choosing to pursue careers in physics with hopes that they can achieve happiness within the discipline. However, it should also serve as a reminder for educators to support the overall success of Women of Color when we see self-determination goals about having healthy environments, in line with literature showing Women of Color seek environments and safe spaces that promote their holistic success (Ko et al., 2014), as well as positive self-evaluations goals, such as feeling pride/confidence in what one does and taking criticism constructively, in line with strategies by Women of Color to mitigate doubt (Ko et al., 2014). This study also provides evidence that women are driven by a range of task mastery goals which the researchers noticed were related to goal orientations of performance and learning goals (Dweck & Leggett, 1988), mastery and performance goals with approach-avoidance orientations (Pintrich, 2000), as well as maintenance-change orientations (Ford, 1992) reflected in goals about continuously

improving/reaching new goals contrasted with others about maintaining balance/stable jobs. However, we focus strictly on the Ford and Nichols taxonomy of goals, to attend to a diversity of goals, rather than goal orientations. Thus, we suggest that future studies incorporate goal orientations in their analysis to expand on the topic of personal goals.

In addition to the above goals, we noticed that some of the participants clearly identified financial stability as a relevant goal and another explicitly stated money was not a priority. We are unable to make claims regarding this theme due to a lack of participant explanation of what led to these differing perspectives. Considering financial support is a relevant influence for Women of Color pursing physics (Rosa & Mensah, 2016), an intersectional analysis attending to participants' socioeconomic background and other identities could serve useful in identifying factors leading to the different prioritization of material gain goals.

Relevance of Goal Clusters

Furthermore, the analysis of goal contents allows us to identify goals and clusters of goals that may become the basis for intentional and focused institutional supports tailored to individual students. Natasha's prioritization of integrative social relationship goals, reflected by her commitment to equity through mentorship and advising others, specifically Women of Color, provides a foundation of supports that can be provided by individuals that are more familiar with opportunities in her department. For example, her graduate advisor, upon acknowledging her goals, can suggest opportunities they are familiar with or search for

opportunities that can position Natasha in mentorship roles, such as suggesting involvement in Women in Physics societies within their department or communities such as the APS National Mentoring Community. Similarly, identifying Monica's prioritization of affective goals, such as her mental health and happiness, her mentors could support her by reminding her of counseling and psychological services provided by their institutions, as well as providing time off from work for Monica to prioritize time with her family. Implementing this goal taxonomy to outline the goal contents of students alongside them can be beneficial for departmental advisors to provide supports in an efficient manner.

A limitation to the model of faculty providing focused support to students is the assumption that these senior individuals have positive relationships with students. In graduate settings, this assumption is more likely to hold, due to common departmental structures that connect student researchers with formal advisors and dissertation committee members. These structures are not as readily available for undergraduate students who go through coursework guided primarily by course instructors often dealing with many undergraduate students, limiting the possibility of developing a relationship with students where their goal contents can be identified and supported. Thus, it is essential for departments to implement research-based mentorship programs (Carroll & Barnes, 2015; Packard, 2016; Wilson et al., 2012).

This study also highlights the way researchers can contribute to the support of participants, in line with participatory methodologies such as CRNM. The interviewer was able to provide resources relevant to the topics highlighted by participants during the interview. Further clarity of the goals identified through this analysis allowed the researcher to remind the

participants of the resources suggested. We recognize that the resources provided to participants are limited by the scope of the professional and experiential knowledge held by the researchers. Thus, researchers invested in explorations of participant goals through supportive frameworks, such as CRNM, can benefit by developing a compendium of literature and opportunities that can address the multiple goal contents outlined in the Ford and Nichols goal taxonomy in a focused and intentional manner.

Ultimately, we recognize this study provides concrete examples of how the Ford and Nichols goal taxonomy can benefit students in identifying their goals in an efficient manner. Since a rich understanding of students' perspectives is crucial to address the nuances of the goals they describe, we suggest that analyses following this model be supplementary to the relationship between students and advisors, not a replacement to fostering a positive relationship between students and their advisors to facilitate the attainment of their goals.

Limitations

This descriptive analysis of Latina's goals was useful in identifying the diversity of goals; however, it neglected important features of goals, such relationships between goals, goal orientations held by participants, and the factors leading participants to change their goals. Future work should implement a more in-depth exploration of the individual's goal hierarchies and the goal orientations.

Due to the interference of the COVID-19 pandemic while this analysis was ongoing the study findings were not thoroughly member-checked by multiple participants. The pandemic

additionally extended the period of analysis, which is likely to have impacted a consistent implementation of the coding scheme as well as the identified findings. The researchers attempted to mitigate these effects to the best of their ability by incorporating procedures to increase trustworthiness; however, it is important that further studies elaborate on these findings during more stable periods in society.

CHAPTER 6: GENERAL DISCUSSION

In this chapter we synthesize the findings across the studies to address the guiding research questions of the dissertation. This is followed up by a discussion of the limitations of the overall project and a concluding section on practical implications for educators and researchers.

Answers to the research questions

A single generalizable answer to the main question, "How do women in physics conceptualize success?" is out of the scope of the study, since we approach this question from an anti-deficit (Mejia et al., 2018; A. L. Traxler et al., 2016) constructivist approach (Denzin & Lincoln, 2017; Saldaña & Omasta, 2021) recognizing that individual women hold different and equally valid conceptualizations of success in the context of physics. The studies carried out in this dissertation provide concrete examples of how the women recruited for this study think of success in physics that can ultimately help educators guide personal discussions with individual students about their success in physics. The studies in this dissertation answer the question by establishing an awareness that success in physics is a highly subjective concept that requires personal discussions to understand, as well as an awareness that women, including Latinas, have widely varying goals associated with their success. We elaborate on these findings with regards to conceptual metaphors for success, the value of emotions in descriptions of success, and the diversity of goals held by individuals.

Conceptual Metaphors for Success in Physics

Here we begin a discussion with regards to the findings of the metaphor analyses in chapter 2 and 4. In these studies we sought to answer, "what are common characteristics of *success in physics identified in explicit metaphors for 'success in physics'* constructed by *women studying physics at single institution* and *Latinas studying physics across the United States?"*

A relevant conceptualization revealed in chapter 2 is that success in physics is a journey, which incorporates the subjective experiences of women's satisfaction, struggles, hope, and recognition along the way. This conceptual metaphor is further supported by metaphors constructed by Latinas in chapter 4, including metaphors of marathons, climbing up mountains, swimming upstream, and rockets taking off. These metaphor address features of the struggles and allude to the hopes of achieving the top of the mountain and a rocket overcoming gravity. Satisfactions were seen in metaphors such as winning games and building puzzles, as well as emphasis on goals of happiness and entertainment identified in chapter 5. Recognition, as identified in chapter 2, was also seen in the metaphors of the ugly duckling and wearing/owning physics glasses where Ale's duckling is recognized as an inspiration and Natasha is recognized as a physicist. This conceptualization of success in physics as a journey provides a simple analogy that centers the subjective experiences of women studying physics.

The conceptualization of success in physics as a journey goes beyond success as a path (Moser, 1999) in that a journey incorporates an individual's subjective experiences along that path. This metaphor should not detract from conceptualizations of pathways, as it should only provide an emphasis on people's emotional responses to the journey. We do encourage

conceptualizations of journeys and pathways as opposed to pipelines, since pipeline conceptualizations entail people as resources transported through sealed pipes for future use. The conceptualization of pipelines offers a focus on deficits in the infrastructure of the pipes, which may help in addressing systemic issues; however these systemic issues can also be addressed in deficits in the infrastructure of roads and paths, as described in depth by Branch (2016).

A noticeable distinction in the metaphors across chapter 2 & 4 is that some Latinas allude to riding vehicles in metaphors related to the journey, while the participants in chapter 2 did not mention any vehicles. Lakoff identifies vehicles in journey metaphors as the relationships that individuals are a part of (Lakoff & Johnson, 2003). There is literature of Women of Color finding deep value in counterspaces where they can develop relationships with others (Ong et al., 2018). Additionally Indigenous communities, such as the Chinook Indian Nation, have deep cultural connections to vehicles, specifically canoes, that are central to community building as well as maintaining their culture (Daehnke, 2017, 2019). Although our sample of Latinas' metaphors did not make an explicit connection between vehicles and community relationships, conceptualization including vehicles can incorporate elements of community valuable to Women of Color and Communities of Color. Relating this to supporting students' success in physics, using conceptualization incorporating concepts of vehicles can encourage students to seek out groups and communities that will help them get to where they want to go. Additionally, these conceptualizations can encourage faculty to build and support student led groups in their local contexts.

Conceptualizations of success in physics as a puzzle incorporate elements of the challenging and enjoyable aspects of learning to use different concepts of physics, which can serve useful in framing physics education. These conceptualizations engage students in ways that are active and center their resources when building knowledge. Additional conceptualizations of success in physics as a growing organism, revealed in chapter 4, are supported by Amy's metaphor for the dandelion. The development of ideas entailed in a dandelion is like the metaphor of growing trees and the fruit they bare, emphasizing the utility of physics ideas developing like growing organisms.

These conceptualizations incorporating aspects of knowledge production should make it clear that women, including Latinas, in physics are very much driven by the desire to contribute to the knowledge of physics community. Success in physics is thus, not only attaining a degree and getting favorable assessment score, but also being able to conduct research and generate knowledge that will benefit the physics community and the world at large. Puzzle metaphors also highlight a sense of satisfaction of dealing with the challenges of knowledge generation, thus educators should be reminded that learning, although it may be a struggle, is also a process that can be enjoyable.

Influences of Emotions Revealed by a Poetic Analysis

The poetic analysis conducted in chapter 3 sought to answer the question, *What insights can we acquire about a participant's choice of metaphor for success in physics?* Our analysis revealed a deep connection between an individual's conceptualizations of success in physics

and their subjective emotional experiences while pursuing their degree in physics. Amy, the participant who contributed to the follow up analysis of her metaphor, discussed at length how her choice of metaphor was the result of trying to frame success in a very positive and enjoyable context with hopes to mitigate other students who may be similarly overwhelmed by descriptions of success centered on struggles. Similarly, Alberta in chapter 2 identified her metaphor of success in physics as a marathon being related to satisfaction metaphors as opposed to struggle metaphors, contrasting all other participants who identified her metaphor with struggle metaphors. This was due to Alberta's deep appreciation of finally completing a marathon which overshadows associations to struggles. Thus, discussing the context of metaphors may reveal values and experiences that are not easily identifiable in the surface features of metaphors.

Diversity of Goals Held by Latinas

Finally, in the study presented in chapter 5 guided by the theoretical assumptions that the most motivating activities are ones that engage a wide range of desired outcomes, we were able to address the question, "w*hat goals do Latinas in physics associate with their success?"*. We found that the Latinas in our study prioritized various integrative social relationship goals (i.e., goals regarding belonging, social responsibility, and resource provision), as well as goals regarding happiness, self-determination, and positive self-evaluations. Some participants were noted to prioritize clusters of goals, such as Natasha who prioritized goals of helping other minoritized students, which satisfied her goals of social responsibility, resource provision, and

equity; and Monica who prioritized affective goals such as happiness, tranquility and entertainment after being overwhelmed by academic goals. Therefore, it is crucial that we have personal discussions to identify the different goals valued by each individual. We hope that these results are not taken as universal conceptualizations or universal goals held by women, including Latinas, pursuing careers in physics.

Limitations and Future Work

This dissertation is limited in the number of responses collected to identify other relevant conceptual metaphors. This limitation is likely due to tension in our guiding feminist frameworks which prioritize the voices of participants and our choice of elicited metaphor analysis which requires large sets of metaphors. The tension became apparent as we compromised in-depth one-on-one feedback from most participants, seen in chapters 2 and 3, to gather a larger set of participant perspectives in chapters 4 and 5. Future studies may incorporate thorough participant feedback from large sample sizes; however, it is important to consider the time and compensation for participants' labor. Along with these elicited metaphors of success, future research should incorporate analysis of metaphors present in spontaneous, everyday language. This method may be more compatible with feminist theories as they allow for a closer look at individual participant stories and reveal unconscious conceptualizations that afford varying levels of agency (Miles, 2014; Paulson & Theado, 2015).

Although we centered the voices of Latinas, we need to be explicit that this was not an intersectional analysis of the perspectives of Latinas with regards to their success in physics. an

intersectional approach to the question of success in physics would make useful for addressing the concerns such as the differences in material gain goals discussed in chapter 5. The lack of Black participants in this dissertation is major shortcoming in the transferability of these findings, thus we call for future work on conceptualizations of success in physics to center the perspectives of Black women, including Black Latinas. This feminist work is also incomplete since we maintained a limited focus on the experiences of women and neglected the experiences of non-binary people, who are further marginalized in physics.

Implications

In this section we present key takeaways from this dissertation and implications for educators and researchers.

For Educators

We established that women hold a variety of conceptualizations of success in physics, such as journeys, puzzles, nature, and sports, as well as a diverse set of desired outcomes ranging across 20 of the 24 goal categories outlined in Motivational Systems Theory (Ford, 1992), Additionally, we recognize that women's success is not only about reaching desired outcomes, since success involves different aspects, such as dealing with struggles and having hope that they will overcome the adversities they face.

As educators, we are implicated to address the range of students' conceptualizations of success in physics to identify and mitigate students' struggles, as well as identify and scaffold

students' hopes. The process of developing metaphors of success in physics served as a useful and engaging method to access various conceptualizations of success, thus the process can facilitate expanding conceptualizations of success beyond assessment scores and number of degrees as metrics of student success. This can be done in classrooms, during conference workshops, and throughout programs supporting underrepresented minorities in physics by gathering metaphors with internet forms that display real-time anonymized results or by writing metaphors in sticky notes that can be grouped and shared for discussion. Generating metaphors may be quite useful for identifying views of success held by students early on in their careers to support their success before students feel discouraged to study physics or before their goals are shifted through socialization.

Educators interested in discussing the student-generated metaphors with students should be cautious with interpreting surface features of metaphors, since the metaphors may have deeper meanings. This was revealed by Alberta's metaphor in chapter 2 and Amy's metaphor in chapter 3; thus, personal discussions should be included when generating metaphors for success. This can be done by pairing students or having students get in groups of metaphors they identified with to engage in discussion. It is worth noting that metaphors are experientially and culturally informed, thus it is important to consider cultural and experiential differences that may influence interpretations of metaphors.

Educators and programs focused on more outcome-oriented conceptualizations of success may find value in implementing the Ford and Nichols (1992) taxonomy of goals as a method to address the various goals available to students. This method can be presented as an

individual development plan to establish a baseline of goals that individual students may desire. This outline of desired outcomes can be used as a student-centered metric of achievement that can be used to keep track of a wide variety of goals relevant to students and how they are doing in achieving those goals. Having the detailed resolution of the goals available can be useful in identifying specific supports for individual goals or supports that can address a range of goals.

For Researchers

This dissertation makes explicit various conceptualizations held by women in physics; however, the effect of holding different conceptualizations is yet to be explored. We encourage researchers to explore the effects of using different conceptualizations of success on factors such as physics identity and personal agency (Doscher et al., 2015; Godwin et al., 2016), as well as effects on attitudes towards physics and performance in classroom assessments. The development and prioritization of different conceptualizations of success within an individual is also unexplored in this study and should be addressed to expand on this descriptive analysis. Additionally, participants contributing to the analysis suggested that reviewing their metaphors was somewhat therapeutic, in line with uses of metaphors in family therapy (Kopp, 1995; Schmitt, 2015). Considering the traumatic experiences women are likely to experience in physics and the recognition that sources of trauma are not likely to go away soon, it is necessary for future work to explore the therapeutic effects of metaphorical representations of success in physics as it pertains to people from historically marginalized communities.

A wide range of theories and methodologies were implemented to mitigate the misappropriation of participants' perspectives because of the privileged and experiential differences between the lead researcher being a man and participants who are women studying physics. The power differential along the dimension of gender is made explicit by the researchers in this study due to the explicitly feminist purpose; however it is crucial to recognize power differentials are inherent in the researcher-researched dynamic and will play a role along dimensions of career stage, age, citizenship, race, and more (Harding, 2007). Therefore, researchers are also implicated to continuously address biases in their interpretations since we recognize certain language, especially language that is metaphorical, can necessitate high inferences. If we intend to follow frameworks that center participants intended meaning, researchers must include participant throughout studies before and beyond initial data collection and traditional member-checking (Koster et al., 2012).. Including participants in the research process validates the outcomes of research in participant lives and furthermore serves as opportunities for the personal and professional development of participants. An example of this is conducting a participatory study of the experiences of Learning Assistants in introductory physics courses which may provide Learning Assistants with first-hand knowledge of physics education research and, if compensation is adequate, may also be a source of money for students who need it.

In addition to including participants in the research process, it is crucial for investigations into the experiences of marginalized people to be led by investigators who share identities along dimensions relevant to the studies to minimize the epistemic distance between

the researcher and those being researcher. Doing so can provide experiential knowledge to inform the selection of relevant methodologies, as outlined in Critical Race Nepantlera Methodologies and other critical theories (Acevedo-Gil, 2019; Calderón et al., 2012; Solórzano & Yosso, 2002). The lead researcher in this dissertation recognized that his choice of methods, e.g. card sorting to identify themes relevant to participants, could be substituted with more culturally responsive methods such as focus groups to reach consensus of relevant themes (J. N. Hall, 2020), although his involvement in a focus group for women would likely compromise the outcomes. Researchers should still be aware of dimensions of identity which privilege them to incorporate methods that mitigate misappropriation; however, researchers should ultimately be empowered to lean into their identities as their experiences may be relevant sources informing the research process.

This dissertation marks a set of starting points regarding the meaning of success in physics from the perspective women, along with a closer look at the perspectives of Latinas. However, we understand there is more work to be done to connect these conceptualizations to effects in the everyday lives of students. Therefore, we encourage researchers and educators to pursue the questions of “What does success mean?” and “Who gets to define success” and answer them in their local context, so that we may continue supporting the attainment of the wide range of unexamined goals of members of the physics community.

APPENDIX A
INTERVIEW PROTOCOL FOR PILOT STUDY

Pre-Interview

A. Welcome Script: Welcome [insert participant's name] and thank you for your participation! My name is Brian Zamarripa Roman, the primary researcher for this study.

B. Introductory Narrative: The purpose of this study is to make explicit beliefs of success as held by women in physics.

C. Informed Consent: Share Explanation of Research

D. Interview Overview: During this time, we will cover three topics. I will elaborate on each topic as we go through the interview. You will be given as much time as you need to respond to the prompts. Feel free to not respond if you are not comfortable. This interview should last approximately 60 minutes or as long as you would like to keep discussing. Thank you so much for your participation!

E. Introduction/Rationale: The purpose of this interview is to get an understanding of what success looks like to you. We often emphasize the need to be a successful physicist, but rarely give explicit examples of what that success looks like. Having this discussion will give us a better idea of what success is.

F. Goals & Expectations: My goal for this study is to address concrete examples of success and to discuss the ways that physics allows this success come into fruition.

Do you have any questions, comments, concerns before we get started?

Start recording.

Is it okay if we audio record this interview?

Topic Domain I: Landscape

In this first section we will discuss your views of success in general

1. Where are you from? [Ice breaker, Covert objective: demographics]

2. What are some important aspects of your life? (What are some important values to your life?)

3. In general, what is success to you? (How do you define success?) (What does success mean to you?)

[Follow-Up Probes: elaborate on specific mention, inquire on personal/academic/career success]

4. What is physics? (How do you define physics?) (What does physics mean to you?)

Topic II Domain: Success in Physics

This next section is to address your views of success related to physics.

1. How long have you been working with physics?

[Follow-Up Probes: current position, years in college]

2. Complete the thought: Physics has helped me achieve success by…

3. Complete the thought: Success in physics is like…

[Follow-Up Probes: Why?]

4. What obstacles in physics make it hard for you to achieve success?

5. What makes a successful (current position)? [perspective of success at expertise]

6. What do you think society expects to be considered a successful (current position)?

7. What do you think are a man's perceptions of success in physics?

8. Is there anything else you would like to share about your views about success in physics?

Topic III Domain: Success in Physics

This next section is to address your views of success related to physics.

1. What things outside of physics make you feel successful?

2. Outside of physics, what do you think society expects for you to be successful?

Topic Domain IV: Message to the Future

For this last section we will try to reposition your responses. It is necessary for us to get these perspectives of success to a younger audience to let them know what success is like in our field. So for these next few questions, try to answer them as if you were going to be sharing the responses to a middle school girl that is interested in physics.

1. Tell us about yourself?
2. What are some of the most important aspects of success to you?
3. What has been your most memorable experience that made you feel successful?
4. When did you realize that you could achieve success with physics?

Conclusions:

1. Before we conclude this session, is there anything else you would like to share?
2. Is there any questions that you think could have been asked better?

[Objective: Strengthen interview protocol]

3. Is there any questions you wish I'd ask?

[Objective: Strengthen interview protocol]

Post Interview Comments and/or Observations:

Demographics Questions:

Feel free to write in a response that best answers the following demographic questions. You may skip any questions you do not want to answer.

With which racial and ethnic groups do you identify?

How do you describe your gender identity?

How do you describe your sexuality?

How do you describe your relationship status?

Would you say your socioeconomic status is above, below, or about the average?

APPENDIX B
LONGER TEXT OF METAPHORS OF SUCCESS IN PHYSICS AT SINGLE INSTITUTION

Helen: Having a Clean Desk

Gosh this is hard. I'm trying to shape the words. Success in physics is like umm, just this satisfying 'cause whenever you do a physics problem and you like get it and you get an answer and its just like, "Yeah I did it, it's real!" I'm trying to think of the words that could shape that into a metaphor (laughs) Umm Its like, it's satisfying, that's not a metaphor … success in physics is like whenever you clean off your desk and everything is clean and organized you're like everything fits together nicely and it's just like, "Yeah!"

Lynn: Biting into a Caramel Apple

I'm gonna have to think hard about that. I'd say a caramel apple. It's pretty sweet. You know. But once you bite into it, it's some tartness. It's not always easy, I guess to get through it. It could get a little messy. But I think overall it's a very good dessert. It's a good thing.

Amazonia: Winning the Lottery

Success in physics... (inhales deeply) success in physics... (long pause, chuckles) winning the lottery (laughs) Physics is a lot of people, first of all confuse what it is. A lot of people feel like they're stuck doing one thing in physics and they don't realize that with a physics degree you can do many things like finance and all these other things that you can do. Its a very- its a difficult science to do, but it's very rewarding. And it's basically like winning the lottery, you win the lottery, so you get it, so you get your physics degree. Now you gotta invest and flip it (laughs) and that's what you could do with a physics degree. You can go many ways with it. People just think you're just stuck in one track and you're not.

Some of it is luck, (laughs) some of it is luck I would honestly say because once again it would lead back to my background. I would say that- I would say maybe a little bit it was luck that I am where I am, but I also applied myself, so you have to buy into that luck to get it. So that's what I did, I bought into it and I was the lucky winner.

Citlali: Jumping out of an Airplane

The exhilaration of jumping out of an airplane! It's that rush!… I've never done it, but you could just imagine. It's like you know, when things are going right with physics and you've figured something out and it's like nobody else has ever done it and I've done it and all the pieces are coming together. When everything goes right, I mean, it's a rush. A total rush. Doesn't happen very often (laughs) It's a rush! Yeah.

Samaria: Getting Water from a Well

Success in physics, I imagine, is knowing more about things. Umm, Yeah. Knowing more about things but never really knowing all of them. So I suppose it's like dragging a pail and getting some water out of a well. But just like using like a cup. You know like a standard cup and just using that to get a little bit of water and you just keep trying to get more water and trying to get all the water from the well, but you can't obviously 'cause you're just using the cup… Umm, the cup is just spending time, I suppose, researching, yeah. Research I imagine, yeah. yeah.

Pluto: Being an Actor

It's like you're an actor, and everyone watches your movie, on the theater… I feel like this is the way I present myself to the world. It can be like the world to me, it can be just a small community that I interact with. But I feel this is the same way actors do. You know, they just present themselves somehow in different movies, and everyone sees that, and everyone enjoys that. And to me, physics is like that.

… I feel like this is, it gives me the chance to present the best of myself. Um, and maybe it's just because I felt like, oh my god, this is something I, there were a lot of things that I went through, you know, like music, and like, like, um acting classes, and sports. Um, and I always try to really, you know, like be good at not just being good at everything, but the ones that I like, I really try to really be good at it.

But I think physics was the only thing I felt like, um, I like it, and also I can be good at it, you know. Like, there were things that I really liked but I was not good, or there were things that I was really good but I wouldn't look at them as just something that I want to do as a main theme of my life. You know, those could be like hobbies, but they were not like, like the main path of my life. So, physics was the only thing that I enjoyed, and I tried to be good, and I feel like I could be good.

It's not I was good all the time, I was trying to be good at, um, and there were times I was happy with what I'm doing, so I had this feeling of satisfaction and like confidence that was built up. Um, and a lot of them not, but I could see, it's just coming in so I have to try for it. So I think yeah, that's why I feel like this is the way I can present the best of myself, to everyone, so...

Amy: Blowing a Dandelion

You know that plant? It's a weed. I think it's a dandelion. The one that grows in with a puff ball. And then you blow on it and make a wish. That's success in physics… Because it starts with just this little idea. And then it grows into these possibilities. And you, all you have to do is

breath and then they go into the universe. To be explored by other people. And that's success in physics.

Renae: Running into a Door

Renae: So success is physics in grad school feels like running into a door, knowing that at the end the door will be opened for you, but you have to keep running into it.

Brian: How fast are you running?

R: Well see, depends on like, how badly you want to get through that door (laughs). Like, the faster and harder you run into the door, the sooner it might open for you (laughs). …Yeah it's, it's gonna hurt but, at the end, and at the end it will open because your professors will be like oh, obviously you've run into this enough times now, so you can pass.

B: And at what point do you know the door's open?

R: When you fall through, and you're like uh, what? There are things, I'm not running into it anymore? I don't really know because I haven't actually gone through the open door yet (laughs). I'm still running into the door. Yeah.

B: What do you think it's gonna look like in your physics career when the door opens?

R: Um, I'm hoping that it's not just a room full of corridors and I get to choose which one I get to run into next.

B: Like do your own research and stuff?

R: Yeah I'm hoping it's just like, I get outside and I can just like go climb a tree or fly a kite.

B: Literally? (laughs) Or metaphorically?

R: That'd be cool. But it's like, atmosphere stuff, yes. No I mean just like, I would love to have the freedom to like do whatever type of research I want, but I know that's not completely realistic because I know there are always going to be some sort of constraints, some sort of rules that will make everything difficult. Because for some reason people have to put rules on everything, everything annoying. But, that's just kind of how things go.

Alberta: Running a Marathon

Hmmm, metaphors. I'm very bad at metaphors. But I'll try: success in physics is like running a marathon. No one thinks it is easy and when you're done you get a medal to show off, but the real work starts long before race day. The real work is the months and years of the day in and day out training that prepare you for future opportunities. The perception of success only comes when you grab an opportunity one day and get to show off a cool result.

APPENDIX C
METAPHORS FOR SUCCESS WITH CORRESPONDING A PRIORI CODES

Table 8: Metaphors for success with corresponding *a priori* codes.

Metaphor	**A priori codes**		
	Ontology and Sentiment[a]		Attributions[b]
	Processes	Products	
Helen: Having a clean desk	addressing problems	understanding problems and their solutions	Int: effort (uns)
Lynn: Biting a caramel apple	getting to upper-level physics	understanding of universe, complex problems	Int: courage to try
Amazonia: Winning lottery	applying oneself, applying degree	degree attainment	Int: applying oneself, personal background (uncon)
Citlali: Jumping out of a plane	taking risks, watching things go right	exhilaration	Int: courage to try Ext: positive outcomes
Samaria: Water from a well	continuously studying	gaining more knowledge but not getting it all	Int: effort duration, learning ability (uns)
Pluto: Being an actor	presenting one's best self	audience enjoyment	Int: skill development (uns), skill capacity (uncon/stab) Ext: others' interest
Amy: Blowing a dandelion	developing and sharing ideas, for others to explore		Int: sharing outcome Ext: others' interest Int/Ext: collaboration
Renae: Running into a door	confronting adversity until the effort is recognized	not encountering difficulties, confronting more difficulties, freedom to choose path	Int: effort duration and magnitude Ext: mentor recognition (con/uns), outcome certainty (stab)
Alberta: Running a marathon	training in advance, taking opportunities, sharing results	positive results	Int: training effort, taking opportunities, sharing outcomes Ext: opportunity availability (uns)

[a] Sentiment denoted with green text with broken underlines for Positive, red text with solid underline Negative and black text is neither.

[b] Internal (Int) and External (Ext) attributions coded Controllable (cont) and Uncontrollable (uncont), respectively, unless noted otherwise. Stable (stab) and unstable (unst) coded when relevant.

APPENDIX D
COMPLETE LIST OF METAPHOR CATEGORIES GENERATED BY PARTICIPANTS

Table 9: Complete list of metaphor categories generated by participants.

Coder	Category label	Metaphors in category								
		A	B	C	D	E	F	G	H	I
Helen	sounds terrible, exhausting				1	1	1		1	1
Helen	positive, agree with	1	1	1				1		
Helen	small size		1					1		
Helen	medium size	1				1	1			
Helen	big size			1	1				1	1
Helen	recognition			1					1	1
Helen	single action		1		1			1		
Helen	journey, keep doing it	1		1		1	1		1	1
Helen	freeing			1	1			1		
Helen	trapping, small space	1				1	1		1	1
Lynn	peace of mind	1	1		1		1			
Lynn	possibilities, future focus, opportunity			1				1		
Lynn	struggle, process, journey					1			1	1
Lynn	happening to you			1					1	
Amazonia	luck, hoping for a wish			1				1		
Amazonia	platform for presentation	1					1			
Amazonia	bittersweet		1		1					
Amazonia	struggle before realization of worth					1			1	1
Citlali	slow process, involves work, consistently doing a long time					1			1	1
Citlali	feeling, emotion, emotional experience	1	1	1	1			1		
Citlali	negative					1			1	
Citlali	positive and negative		1							1
Citlali	positive	1		1	1					
Samaria	painful process, journey, marathon		1			1			1	1
Samaria	satisfaction, sunsets	1		1	1			1		
Samaria	outcome oriented	1			1		1	1		
Samaria	process					1			1	1
Samaria	inactive			1				1		

Coder	Category label	Metaphors in category								
		A	B	C	D	E	F	G	H	I
Pluto	temporary excitement, simple actions		1		1			1		
Pluto	journey					1	1		1	1
Pluto	working for a performance						1			1
Pluto	sports								1	1
Pluto	projects	1		1		1				1
Amy	pleasure	1		1	1			1		
Amy	pain					1			1	1
Amy	pleasure and pain		1				1			
Amy	short time		1	1						
Amy	medium time	1			1			1		
Amy	long time					1	1		1	1
Renae	live action, punishment, story		1			1			1	1
Renae	state of being, emotion, outcome, feeling	1			1		1			
Renae	passive process, taking a chance			1				1		
Renae	positive	1	1		1					
Renae	negative					1			1	1
Alberta	negative		1			1	1		1	
Alberta	accomplishment, upbeat, life is hard but we can do it	1			1			1		1
Alberta	external factors, hurdles			1					1	
Alberta	struggle		1			1				
Alberta	looking back			1		1	1		1	
Alberta	looking forward	1	1		1			1		1

Metaphor key: A) Having a clean desk; B) Biting a caramel apple; C) Winning the lottery; D) Exhilaration of jumping out of a plane; E) Dragging a pail to get water from a well; F) Being an actor; G) Blowing a dandelion; H) Running into a door; I) Running a marathon

APPENDIX E
INTERVIEW PROTOCOL FOR STUDY FOCUSING ON LATINAS

Pre-Interview

A. Welcome Script: Welcome [insert participant's name] and thank you for your participation! My name is Brian Zamarripa Roman, the primary researcher for this study.

B. Introductory Narrative: The purpose of this study is to make explicit perspectives of success held by Hispanic women in physics, so that the physics community can align its practices to better serve those with similar views of success.

C. Informed Consent: Share Explanation of Research

D. Interview Overview: During this time, we will cover multiple aspects of success and physics. I will elaborate on each aspect as we go through the interview. You will be given as much time as you need to respond to the prompts. Feel free to not respond if you are not comfortable doing so. This interview should last approximately 60 minutes or as long as you would like to keep discussing.

E. Rationale: As a physics community, we often emphasize the need to be successful physicist, but rarely give explicit examples of what that success looks like. Having this discussion will give us a better idea of what success means in this context.

F. Goals & Expectations: The goal of this interview is to discuss what success means to you.

Do you have any questions, comments, concerns before we get started?

Is it okay if we audio record this interview?

Start recording.

Is it okay if we audio record this interview?

Topic Domain I: Conceptualizations of success and physics

In this first section we start with an ice breakers and then discuss your perceptions about success and physics in a broad sense.

1. Tell me about your cultural background and your academic background? [Ice breaker, Covert objective: demographics]

2. Tell me about what success means to you. [Conceptualizations of success]

3. Tell me about what physics means to you [Conceptualizations of physics]

4. Complete the thought with a metaphor or analogy "success in physics is like…" How so? What does ____ represent in your metaphor? [Conceptualizations of physics and success]

Topic II Domain: Properties of a journey

This next section is to address the different parts of your journey in physics.

1. How did you begin pursuing a degree/career in physics? [Starting point]

2. What do you hope to be doing with a degree/career in physics? [Future direction]

3. In what ways do you consider yourself successful or not successful? Why or why not? [Destinations/Checkpoints]

4. What is necessary to achieve your success in physics? [Expected attributions]

5. What has made it difficult to succeed in physics? [Obstacles]

6. What has helped you succeed in physics? [Tools and supports]

7. What can your physics department do to help you succeed? [Community suggestions]

8. When you think about physics, what emotions do you feel? Why? What about physics makes you feel [specific emotion]?

9. In which other areas, aside from physics, does success matter to you? [Parallel paths]

Topic Domain III: Social perspectives of success

In this section we will try to make explicit what you think others think about success in physics. To do so we'll complete this meme format. Think of up to 5 people or entities whose perspectives are relevant to you and write down a few bullet points about what you think they think is success in physics is for you. Please think-a-loud as you complete it.

SUCCESS IN PHYSICS

What _____ thinks it is.

What _____ thinks it is.

What _____ thinks it is.

What _____ thinks it is.

What _____ thinks it is.

What I really think it is.

Conclusions:

1. Before we conclude this session, is there anything else you would like to share or questions you wish I would have asked? [Strengthen interview protocol]

Post Interview Comments and/or Observations:

Demographics Questions:

Feel free to write in a response that best answers the following demographic questions. You may skip any questions you do not want to answer.

What is your intended degree?

With which racial and ethnic groups do you identify?

How do you describe your gender identity?

How do you describe your sexuality?

How do you describe your relationship status?

Would you say your socioeconomic status is currently above, below, or about the average?

How about your socioeconomic status growing up?

APPENDIX F
LONGER TEXT OF LATINAS' METAPHORS AND RESEARCHER INTERPRETATIONS

Ale: The Ugly Duckling (with example notes)

“As a person of color, success in physics is like the ugly duckling trying to be the beautiful swan because you have everything turned against you. Nobody really thinks you'll make it. As a person of color It's not a field, where a lot of people of color are in or a lot of women are in or a lot of women of color are in. So to make it you kind of became a beautiful swan and they have everything going now. Um, I think the beauty is to just make it and become an inspiration to other women of color. To let them know that just because you're the only woman, or the only person of color in your calculus class and only woman of color in your physics class, the only girl in your math class, that you're still going to make it even though everything's stacked against you, You have that. You can always look up because there's somebody else that already has made it.”

Interpretation: Success in physics is overcoming the adversity experience by women of color, such as being one of the few women of color in their physics setting or dealing with others' negative perceptions of them, so that they may become a source of hope for other women of color persevering through their own adversity.

Notes: It is unclear at what point one becomes a beautiful swan and "makes it", however the expression "make it and become an inspiration" provides the clue that becoming an inspiration is "making it". Adding “hope” because it's more than inspiration to persevere, its much closer to hope as seen in past work.

Arienette: A Tree (with example notes)

“A tree. I think a seed was planted and I think action was taken down through the roots. It has, it has to start. It's a challenge. A tree doesn't just grow, it has to grow its roots first. It has to get down into the depths of the ground before it can shoot up into success and bear fruit. So I think that success for all physicist is kind of like a tree. You have a thought that was once planted in your head and only you know that thought and you're going to go through challenges and obstacles and you're going to dig into those roots and into that ground of what, where, where you're placed. And I think that the fruit that you bear is going to be the knowledge that

you have found for physics. It's going to be your piece of the puzzle. It's going to be your fruit to the world, if you will."

Interpretation: success in physics is having an idea or thought about physics and developing it by supporting it with previous knowledge and one's own experiences to overcome challenges until that idea is formalized into physics knowledge. That knowledge would then be shared with the rest of the world and become a contribution of the worlds' understanding of the physical phenomenon.

Notes: The aspects of developing an idea or thought into knowledge that can be shared is pretty explicit. The process of how to develop an idea is not that explicit except for "digging into the roots and ground of where you're placed" this gives me a clue that the development is more related to supporting the idea with the individual's experiences and knowledge.

Connie: Learning and Teaching how to Ride a Bike

"Learning to ride a bike and being able to teach someone else how to ride a bike because I feel like you're learning these concepts and once you have basics down you can do more interesting things. So once you, uh, have learned to ride with training wheels, then you can get off the training wheels and then you can go for longer rides. Uh, but I feel like you don't really understand it unless you can communicate it to someone else. So teaching someone else how to ride a bike is, I think equally as important as learning how to go on those long bike rides yourself.

(Training wheels) I think, um, well, high school, my high school physics class was very different from the college classes I've been taking. Um, and I've just talking amongst my peers, everyone seems to have enjoyed the high school physics class, but people seem to hit a bit of a roadblock or it's more challenging in college. So, um, I think making it accessible and in the first place is important because people will want to be interested. But once you take those training wheels off and it becomes a little more challenging, you know, the math is at a bit of a higher level? Um, it's important, you know, if you're interested to stick with it. Um, even once the training wheels are off [inaudible]"

Interpretation: Success in physics involves learning how to use the basic concepts of physics and math in a low stakes environment to the extend that one is able to explore more complex phenomenon on their own. The success also includes achieving a more thorough understanding of the phenomenon that can only be acquired from teaching and communicating that knowledge.

Edith: A Rocket Taking Off

"A rocket taking off. First You have to really like escape whatever is pulling you down. But then once you cross that threshold, you're just flying and you're, you're not cruising, but like you, you've made it, you've passed that thing that's pulling back and then you're ready to face on like new obstacles. Um, I think it's self doubt and a lot of that like "why are you doing it in the first place?" And finding your purpose and sense in why you're doing physics in the first place. Because it is very difficult just like, you have to take calculus and you have to put the work in and um, if the rest of the things in your life aren't allowing you to do it, like that in itself is just a challenge. So finding the reason to keep you motivated into doing it, no matter how interested you are in it, I think is one of the things that can feel like it's pulling you down.

(Pulling back) Um, I think working against, okay, um, maybe like family values. Where, um, well in my case, like my family meets up every, every weekend or every holiday and you know, you have to put in that time to meet with your aunts and your all your cousins. And if you're not there, it's like, you know, everyone afterwards it's like, Oh, well where were are you? Like you're always so busy. And it's like, like I still care about my family but I have to stay in this weekend to study because if I don't like I'm not gonna um, I'm not going to be able to like stay on track for the things that I want to do. So I think that whole balancing thing, again, I think working through that can also feel like, it's pulling me down because maybe my family doesn't understand the amount of time that it takes to get through a problem or you know, it, it takes for me to personally just to focus and do stuff without worrying about how my family feels about it. Um, I think Also large part is working against like what other students will think if like I don't do well on something and it's like I don't want to have to think about that. I just want to do physics and if like one grade is going to determine whether or not I keep moving forward. That's pretty stressful.

(Threshold) I guess. I think a lot of this threshold is coming to terms that like, yes, like I do belong in physics. Like that I have found my purpose in physics and that no one that, that thing, that purpose is mine. And that only I know if I'm actually meeting my own standards for it. Um, so like, especially my thing is like calculus, like I get a lot of math anxiety ironically, and um, I may not get, You know, I used to beat myself up for, um, no doing so well on the exam, on

the calculus exams. But now that like, I'm like, yes. Like I can, I may not, I may need some help or may need some extra time to get through calculations for physics, but at the end of the day, I know what I need to do. I know that that doesn't make me any less of a physicist because I do need just like a little extra time. And I know that ultimately my purpose is to, my purpose is to help, uh, teach physics and also to help teach ethics in physics. And, um, once I realized that I feel like I can, I feel calmer, I can focus a little better about, on, on my studies. And like I said, like once I reached that threshold, it's like confidence, I guess. Um, once I reached that threshold, I can reframe things and say, okay, I need a little extra time here. But once I get to do that, I just have to focus on, um, completing this other project. It's like all these other hurdles. And I think, I think that threshold is confidence. And, um, once that confidence kicks in and that like feeling of belonging and feeling of this is my purpose within the physics community, then everything sort of falls in place because then you're not meeting other people's standards of like, you have to get hundreds all the time to be a good physicist. No, I just have to understand how I work and how I can contribute to physics. And that's, that's it."

Interpretation: success in physics is overcoming self-doubt activated by others' standards and expectations (such as family's expectations of time spent with them or peers' expectations of the amount of time spent solving problems or what constitutes as good grades) and having the confidence to set one's own standards of what it means to belong in physics and contribute to the physics community.

Francesca: Putting a Puzzle Together

"Putting all the pieces of the puzzle together, but the puzzle is just a white piece of paper or like a white square. So you have to figure out what it's supposed to be.

I heard that metaphor one time had to describe research and I thought we would make perfect sense for physics because we kind of know that it's supposed to be a white square at the end, but we don't really know if all of your pieces are just white [inaudible]

The piece would be, you have the pieces of everything that's been found before. When I think of physics, I think of ongoing research. You have all of the stuff that's been discovered before, even up to quantum and all the space physics that we know now that we didn't know before, plus the Newtonian plus everybody else who came before us. All of those, those make up the outline or the outside pieces of the puzzle where you know that they're the outside, because they have the flat border and then as you continue researching you get closer and closer to the middle. Then the final piece would be the middle one that ties it all to the other. And that's like your scientific discovery and that's what makes it a success."

Interpretation: success in physics is achieving a scientific discovery through connecting a wide range of fundamental physics concepts developed by predecessors.

Helen: Running a Marathon

"I would say a running a marathon, that's the first thing that comes to my mind 'cause it's a very long process and you have to really love it in order to stay in the race. So once you finish a marathon, you feel like really great. I think that's the same feeling that you get when you either finish one problem in physics or when you finish like your graduate degree or just your undergraduate degree. I think that would be like success 'cause I have run marathons before. So I know that really hard feeling that you get towards the end."

Interpretation: success in physics is a long term process, requiring commitment to persist through the end. It leads to feelings of deep satisfaction when achieving objectives such as answering a problem or earning a degree.

Isabel: An Over Saturated Sponge

"An over saturated sponge. Like there's so much that we're learning. It's sometimes so much. The sponge is your brain. (And then what's it saturated with?) Knowledge."

Interpretation: success in physics is having to learn an overwhelming amount of knowledge.

Luna: Solving a Puzzle

"Solving a puzzle. Like solving I guess. Yeah, I could start with that. You know? Well you have a very complex puzzle that not all the pieces are there. There's like sub pieces to a pieces because, with each piece would be like each sub field and with each sub field would be like each tool that you utilize. So you have all of the different kinds of like equations that you need. like for example if you're doing like their, what dynamics have or like statistical mechanics,

right? You have a certain set of like tools that you utilize for that week. And so that would be one whole piece. And then its many. “

Interpretation: success in physics is solving complex problems with unknown variables by integrating the knowledge of the sub-disciplines of physics.

Melissa: Climbing a Really Tall Mountain

“Climbing a really tall mountain and then when you finally get to the top and you can finally take a breath, relax. That's when you're successful. what is the, what is the tall mountain Mm. School education, like getting all the tools you need to be in a place in your career where you, um, have like freedom, kind of. Cause I feel like when you're new to the field, it's kind of like you're just really hoping for like chance and good opportunities, but then when you're like a established professional, there's, there's so many more options, so many more things open to you. Cause you're already established that you're great. You know.”

Interpretation: success in physics is the hard work and effort to achieve a professional standing where one has more opportunities and is able to pursue their desired goals.

MJ: Energy

“Energy for me. Because, um, relating it to, to my everyday life. Um, that well, with what I have, that just like brings down my, my energy every, every second. Um, I would say like when I'm, when I'm doing physics, when I'm in physics class, when I'm just doing something relating to it in general and just it energizes me. “

Interpretation: success in physics is doing physics to get motivated and energized.

Monica: A Balance

“A balance. So I would say is, yeah, it's kind of like a balance to me, like weights, like one side and the other, kind of like trying to figure out where working everything being equilibrium. So, I guess that is in a way would it be like for me, so that, I don't know if that makes any sense, but to me personally it's that. So the weights that I'm trying to balance, you know, are, is like

the workload, um, my research and all that. And on the other end, you know, being involved in committees or whatever it may be and helping other, you know, students and things like that. And then the on the other side is my family, my health was physically and mentally finances, all of that stuff. Um, you know, and yeah, just like my parents and all that as well. Cause you know, I'm the retirement plan, right. So it's kind of balancing all that."

Interpretation: success in physics consists of sustainably managing the responsibilities of coursework, research, community service, family, finances, physical and mental health

Nandy: Stargazing at Night & Being on the Beach

"Stargazing at night with no troubles in the world. Being able to just think about and understand and be able to live the moment, um, with the sky without any other worries in the world. I know that's a long answer."

"Being on the beach and watching the waves crash. Um, and also just like also without any worries in the world, just like being able to enjoy the, the waves and the environment, but also as a physicist, I'm able to like think about that. I think about the physics of it and without any worries in the world, you know, just be able to see it and be like, ah, I know what I, what's going on? So kind of like that is what I was thinking for stargazing part is like, Oh yeah, like I know what's happening without any worries. So it's basically being able to enjoy and understand what you love without any other outside pressures, um, or anything that affects you"

Interpretation: success in physics is being able to enjoy and understand the moment with a sense of calm without worries.

Natasha: Wearing and Owning Glasses

"Wearing and owning glasses and being a bad ass while you are doing it. That's essentially what I would say. Yeah. So m wearing and owning the glasses. One thing is for people to recognize you that you have the physics glasses on or that you're a physicist. And uh, that I think it's helpful to some extent, but then there gets to a point where I say owning the glasses, it's when you recognize that the little person inside, whether it's that younger girl or that scared person that's inside you, you allow yourself to actually think, "you know what, I'm actually a physicist and I realized that I put in the effort and I've earned this. Um, regardless of

how really crappy it feels sometimes." And regardless of how, uh, I would say because of my path, the fact that I didn't choose physics since I was in high school, I never took physics in high school. I was actually aiming to be a medical doctor and then I switched over 180 and I was like, "no, I'm going to be a physicist." Um, because of that path, I think like sometimes it's like "do i really want this or what am I playing at?" And, uh, but, and that's what I mean by owning the glasses of like, "yup, I made this choice. I'm here and I'm, I'm ready to do what it takes and not let it push me out because it says that I, because it, physics says that I don't belong."

Interpretation: success in physics is being recognized as a physicist by others and recognizing oneself as a physicists despite the adversity experienced when choosing to become one.

Nicky: Being the First to the Moon.

“Being the first to the moon. So it's a race to succeed. But it's also a race to expand the knowledge and to make an impact in the, in the like, so it was like a race to get to the moon. So it was everybody was impacting each other and influencing each other to work harder and faster. I mean like any innovative design. Pretty much. Any innovative design or any new theory or concept.”

Interpretation: success in physics is developing innovative scientific knowledge through a mutually beneficial competitive process.

Pink: Putting a Puzzle Together

“Being successful in physics is, is, um, difficult as like, if you mean that like, Oh, you've, um, like discovered something, you know, like you've contributed to, um, to something like physic to the physics, physics in that way. And like, I think that's hard. Um, like research is hard. I think, at a lower level, like intro stuff, like what most STEM majors see cause most STEM majors have to take physics. Um, it's, it's not, it's like, um, it's like building a puzzle. You know, you just put it together. Like for lower level, that's what it's like. Um, right now I'm just entering the upper division and, uh, it's a lot of math. It's a, but I'm good at math, but it's difficult to apply it to, um, physics cause it's a new way of looking at math. Um, I don't know. I don’t know what physics is like.”

Interpretation: success in physics is contributing to physics through research by learning the fundamentals of physics and integrating that knowledge.

Rachel: A Roller Coaster

"A roller coaster. It's hard, because I don't know, I see my professor here and then I think they are kind of successful because you know they're doing what they like. And then I talked with them about it, you know, the research they're doing or something and they're like, they like, they have to do so much or put a lot of work into it and kind of suffer In a way, to be able to, you know, finally get to whatever your goal is. And then, you know, I think that's pretty much everything in life. But I think of physics, it's still, it's harder because, you know, most people don't really get enough importance out of physics. [inaudible] I will say downs. When you don't have a budget, to do whatever research you're trying to do or you don't have the support or the people that'd be that [inaudible] you. Um, and up, whenever, you know you do get, all those things or you find something new. Uh, you know, a new discovery, you know, Or whatever, you, you, you find that whatever you were thinking it was right. You're, you know, you're, my confidence was right. So that'll be enough. I'm going to give an example of the roller coaster. when you're studying, for example, you think it, it taking forever because it is so hard and you have to study so much and put so much work into it and it takes forever. So that's, you know, the low, you know, slow down and then the lower bumps, and it goes fast whenever it's going, you know Good."

Interpretation: success in physics is a dynamic process trying to do the research that one desires and dealing with the negatives aspects of having to put in the effort to make it happen and at times not having the support to do so.

Rafaela: Staying Hydrated

"Well I'd say maybe like water, like water, it, you need it in your life, like in order to understand a lot of things. Um, and it can be a lot of things. Like it can be a, like it's something fundamental that you should know, but it also helps you and a lot of different things like no matter what you want to do it, um, can give you those skills. Like real problem solving can give you the skills, like some things you specifically learn in your field of research, like programming or working in a lab, which is good for like industry or, you know, also like communication and uh, the math and the, I feel like it's well-rounded. Yeah. No, the reason I said water's because

like water is like so essential because it can like be used for a lot of things. Gotcha. (And so success in, so physics is the water, right? And so success in physics is like...) staying hydrated."

Interpretation: success in physics is acquiring versatile knowledge and skills that can be applied to understand and solve problems in many contexts.

Redlush: Cracking Open an Egg

"Trying to crack open the like an egg for the first time. I didn't know why. Should I explain it please? Please. Why? How so? I think because at least, at least when I was a kid and I was trying to crack open and my first egg like just to cook it, I failed so many times before cracking it open successfully. And I feel that that's just a great analogy to physics because you're gonna fail so many times before you get that successful anything, you know, I feel, yeah. And I feel also like in homework and just with a project. Oh my God. Okay. (B: Yeah, that's what I was going to ask. Like what is the egg in physics, right? And so you said homework projects.) Yeah. All of those things are research project, homework, presentation. Oh no. Yeah. That's the egg."

Interpretation: success in physics is an ongoing process of overcoming failures until one achieves a breakthrough.

Selena: Winning a Basketball Game

"Winning, like a game, like basketball game or something. Like it's not, it's not just one game. Does that make sense? (what are the games?) I feel like, you know, you have the whole season and you have playoffs and you have a championship or like success can be just like a small thing. (Gotcha. And so in the context of physics, what would that look like?) Uh, you know, like publishing a paper or like getting an experiment go really well or something. (Gotcha. Um, so it's, it's more about the, the single aspect. Like it's just one, like one thing as compared to like the long season.) Right. And it's not necessarily about like bouncing a ball or like scoring or [inaudible], it's like, it has to be like winning. Okay. And winning that game is like publishing the paper and then getting the experience. (And so, okay. Um, so what would be like the playoffs and like the championship, I guess?) I guess kind of like right now where I'm at in life playoffs would be like getting this PhD done, like long haul. And then, you know, the championship game or the landing a job that like I can be at my best starting a career I guess."

Interpretation: success in physics is achieving a series of goals in order to achieve long-term goals, e.g. publishing a research article (short-term), completing a PhD (mid-term), or gaining employment in a desired career (long-term).

Virginia: Swimming Upstream

“Trying to swim upstream, um, because I, it's possible, but it's really hard. Um, and I feel like the level of difficulty definitely varies on like, who it is, but I would like to think that we all genuinely struggle in physics. (what is the water that's going up like downstream?) For me, I think for me at my university, I feel like the water is, uh, the lack of tutoring. Um, the lack of help from professors. Some professors are very um, for lack of a better word, they're very full of themselves. Um, they're really like, "Oh, you should have learn this in high school. Oh, how do you not understand it? Like it's very basic stuff." And then I'm like also just like the culture, at least in my physics department it is very, very very toxic. I haven't been in a physics class this semester but I doubt that has changed since the last time I was in that environment. Um, you know, it's very like they want to strip you down and feel less like who you are. and like just very, very belittling sometimes.”

Interpretation: success in physics is a process of trying to learn physics while overcoming adversity, such as a lack of tutoring, demeaning professors, or a harmful departmental culture.

APPENDIX G
INITIAL THEMES IDENTIFIED ACROSS LATINA'S METAPHORS

Table 10: Initial themes identified across Latina's metaphors.

Theme	Domain	Metaphor included in theme																		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
competition	source						1									1					1	
grounding meditation	source		1								1	1							1			
joy	source				1		1			1	1		1	1								
learning a skill	source			1																1		
leisure	source			1		1	1		1				1				1	1			1	
nature	source		1							1			1	1						1		1
physically demanding	source						1			1												1
puzzle	source		1			1			1								1					
seeing being seen	source	1					1								1	1						
space-related	source				1								1			1						
threshold	source	1	1	1	1	1	1	1	1	1					1	1	1			1	1	
traveling moving	source			1	1		1			1						1		1				1
water	source							1											1			1
family responsibilities	target				1							1										
knowledge	target		1					1											1			
struggle with math	target	1			1												1			1		
research	target		1			1				1		1				1	1	1			1	
social hardships	target	1			1										1							1
academic stages	target			1													1				1	

Metaphor key: A) ugly duckling; B) tree growing; C) learning/teaching how to ride a bike; D) rocket taking off; E) putting a puzzle together; F) running a marathon; G) oversaturated sponge; H) solving a puzzle; I) climbing a mountain; J) energy; K) a balance; L) stargazing; M) being on the beach; N) wearing/owning glasses: O) being the first to the moon; P) building a puzzle; Q) roller coaster R) staying hydrated; S) cracking open an egg; T) winning a basketball game; U) swimming upstream

APPENDIX H
GOAL CONTENTS REPRESENTED BY THE FORD AND NICHOLS GOAL TAXONOMY

Table 11: List of in-vivo goals represented by the Ford & Nichols Taxonomy of Goals

Goal Category	**Associated in-vivo goal**
a. entertainment	communicating science doing something you love doing what I love enjoying my work enjoying your job
b. tranquility	coping with everything living comfortably not living stressful or rushed lifestyle not struggling to have money not worrying about rent time for mental health
c. happiness	being happy (pink) being happy (rachel) being happy with what you do being happy with what you're doing being the happiest doing something you love doing what I love feeling fulfilled feeling happy with what you're doing
d. bodily sensations	(blank)
e. physical well-being	a healthy lifestyle not overworking myself well-being
f. exploration	internships
g. understanding	being in astronomy learning more
h. intellectual creativity	(blank)
i. positive self-evaluation	being confident in what you're doing doing a good job doing something you didn't think you could do doing your best exceeding your expectations feeling pride in what you do going beyond what I thought was capable holding myself to standards of morals making a difference seeing better version of yourself trying your best even if you fail

Goal Category	Associated in-vivo goal
j. unity	mirroring values in professional and personal life work-life balance (monica) work-life balance (nandy)
k. transcendence	a goal lasting a long time accomplishing a dream being in astronomy being remembered finding your passion finding your purpose giving back to parents having what you dream of
l. individuality	accomplishing a goal regardless of obstacles finding what you're good at finding your passion finding your purpose making a difference mirroring values in professional and personal life not living stressful or rushed lifestyle
m. self-determination	a healthy environment a healthy lifestyle accomplishing a goal regardless of obstacles breaking the system overcoming systemic boundaries taking criticism constructively time for mental health trying your best even if you fail work-life balance (nandy)
n. superiority	(blank)
o. resource acquisition	awards being considered an expert being well known in field being well respected effort being validated

Goal Category	Associated in-vivo goal
p. belonging	a stable family life
	being a part of astrophysics
	being considered an expert
	being in astronomy
	being inclusive of others
	being well known in field
	being well respected
	belonging to the physics community
	contributing to greater knowledge
	having a family
	motivating others to be into science
	supporting a family
	time for family
q. social responsibility	a goal lasting a long time
	a great career
	a stable career
	a stable job
	a steady job after PhD
	accomplishments
	awards
	being considered an expert
	being well respected
	completing career
	feeling happy with what you're doing
	giving back to community
	giving back to parents
	internships
	teaching another person
	thriving in my field
r. equity	being humble
	being inclusive of others
	equity
	making a difference
	making change and improving world

Goal Category	Associated in-vivo goal
s. resource provision	adding to puzzle of life being able to share communicating science contribute to astrophysics contributing how I can contributing to greater knowledge giving back to community giving back to parents helping people come in motivating others to be into science motivating others with their dreams supporting a family teaching another person working in outreach
t. mastery	accomplishing a dream accomplishing a goal regardless of obstacles accomplishments being considered an expert completing career graduating having the ability to accomplish goals improving and reaching goal making yourself better pursuing the best you can achieve reaching your goals thriving in my field
u. task creativity	(blank)
v. management	being the most productive doing a good job doing what I can making your dream happen pursuing a purpose work-life balance (monica) work-life balance (nandy)
w. material gain	financial stability having what you dream of money providing for myself
x. safety	a healthy environment a stable environment

APPENDIX I
IRB APPROVAL FOR SINGLE SITE STUDY

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

March 11, 2019

Dear Brian Zamarripa Roman:

On 3/11/2019, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study
Title:	Identifying women's success in physics
Investigator:	Brian Zamarripa Roman
IRB ID:	STUDY00000227
Funding:	Name: National Science Foundation (NSF)
Grant ID:	

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Gillian Morien
Designated Reviewer

APPENDIX J
IRB APPROVAL FOR STUDY FOCUSING ON LATINAS

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

October 2, 2019

Dear Brian Zamarripa Roman:

On 10/2/2019, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study, Exempt Category
Title:	Hispanic women's conceptualizations of success in physics
Investigator:	Brian Zamarripa Roman
IRB ID:	STUDY00000914
Funding:	Name: National Science Foundation (NSF)
Grant ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Kamille Chaparro
Designated Reviewer

REFERENCES

Acevedo-Gil, N. (2019). Toward a Critical Race Nepantlera Methodology: Embracing Liminality in Anti-Colonial Research. *Cultural Studies - Critical Methodologies*, *19*(3), 231–239. https://doi.org/10.1177/1532708618819625

Adams, W. K., Perkins, K. K., Podolefsky, N. S., Dubson, M., Finkelstein, N. D., & Wieman, C. E. (2006). New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey. *Physical Review Special Topics - Physics Education Research*, *2*(1), 1–14. https://doi.org/10.1103/PhysRevSTPER.2.010101

Alcoff, L. M. (2005). Latino vs. Hispanic: The politics of ethnic names. *Philosophy & Social Criticism*, *31*(4), 395–407. https://doi.org/10.1177/0191453705052972

Alsop, S., & Watts, M. (2000). Facts and feelings: Exploring the affective domain in the learning of physics. *Physics Education*, *35*(2), 132–138. https://doi.org/10.1088/0031-9120/35/2/311

American Physical Society, & Integrated Postsecondary Education Data System. (2021). *Bachelor's Degrees Earned by Women, by Major*. https://www.aps.org/programs/education/statistics/womenmajors.cfm

Ames, C. (1992). *Classrooms : Goals , Structures , and Student Motivation*. *84*(3), 261–271.

Andersen, H. C. (1843). The Ugly Duckling. In *New Fairy Tales. First Volume*. C. A. Reitzel.

Anderson, E. (2020). Feminist Epistemology and Philosophy of Science. In E. N. Zalta (Ed.), *The*

Stanford Encyclopedia of Philosophy (Spring 2). Metaphysics Research Lab, Stanford University. https://plato.stanford.edu/archives/spr2020/entries/feminism-epistemology/

Anzaldúa, G. E. (2015). Light in the Dark/Luz en lo Oscuro. In A. Keating (Ed.), *Light in the Dark/Luz en lo Oscuro*. Duke University Press. https://doi.org/10.2307/j.ctv1220hmq

Armstrong, S. L., Davis, H. S., & Paulson, E. J. (2011). The Subjectivity Problem: Improving Triangulation Approaches in Metaphor Analysis Studies. *International Journal of Qualitative Methods*, *10*(2), 151–163. https://doi.org/10.1177/160940691101000204

Arroyo, J. L. (2017). *Latina Women in STEM: A Critical Analysis of Ph.D. Students' Experiences*. https://search.proquest.com/docview/1944400252/abstract/F2DCCC8AAA324C40PQ/1

Aycock, L. M., Hazari, Z., Brewe, E., Clancy, K. B. H., Hodapp, T., & Goertzen, R. M. (2019). Sexual harassment reported by undergraduate female physicists. *Physical Review Physics Education Research*, *15*(1), 10121. https://doi.org/10.1103/PhysRevPhysEducRes.15.010121

Aykutlu, I. (2017). An Examination of Pre-Service Primary School Teachers' Comprehension of The Concept of Physics Through Metaphors. In *International Journal of Progressive Education* (Vol. 13).

Banda, R. M., & Flowers, A. M. (2018). Critical qualitative research as a means to advocate for Latinas in STEM. *International Journal of Qualitative Studies in Education*, *31*(8), 769–783. https://doi.org/10.1080/09518398.2018.1479046

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Barajas, H. L., & Pierce, J. L. (2001). The Significance of Race and Gender in School Success among Latinas and Latinos in College. In *Source: Gender and Society* (Vol. 15, Issue 6). https://about.jstor.org/terms

Barthelemy, R. S., McCormick, M., & Henderson, C. (2016). Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions. *Physical Review Physics Education Research*, *12*(2), 1–14. https://doi.org/10.1103/PhysRevPhysEducRes.12.020119

Bernal, M. E., Saenz, D. S., & Knight, G. P. (1991). Ethnic Identity and Adaptation of Mexican American Youths in School Settings. *Hispanic Journal of Behavioral Sciences*, *13*(2), 135–154. https://doi.org/10.1177/07399863910132002

Blakely, K. (2007). Reflections on the Role of Emotion in Feminist Research. *International Journal of Qualitative Methods*, *6*(2), 59–68. https://doi.org/10.1177/160940690700600206

Bodin, M., & Winberg, M. (2012). Role of beliefs and emotions in numerical problem solving in university physics education. *Physical Review Special Topics - Physics Education Research*, *8*(1), 1–14. https://doi.org/10.1103/PhysRevSTPER.8.010108

Bower, G. H. (1992). How might emotions affect learning? *The Handbook of Emotion and Memory: Research and Theory*, *3*, 3–31.

Branch, E. H. (2016). *Pathways, Potholes, and the Persistence of Women in Science: Reconsidering the Pipeline*. Lexington Books.

Brayda, W. C., & Boyce, T. D. (2014). So you really want to interview me?: Navigating “sensitive”

qualitative research interviewing. *International Journal of Qualitative Methods*, *13*, 318–334. https://doi.org/10.1177/160940691401300115

Brewe, E. (2011). Energy as a substancelike quantity that flows: Theoretical considerations and pedagogical consequences. *Physical Review Special Topics - Physics Education Research*, *7*(2). https://doi.org/10.1103/PhysRevSTPER.7.020106

Brewe, E., & Sawtelle, V. (2016). Editorial: Focused Collection: Gender in Physics. *Physical Review Physics Education Research*, *12*(2), 1–4. https://doi.org/10.1103/PhysRevPhysEducRes.12.020001

Brownstein, M. (2019). Implicit Bias. In E. N. Zalta (Ed.), *Stanford Encyclopedia of Philosophy*. https://plato.stanford.edu/entries/implicit-bias/

Butler-Kisber, L. (2002). Artful portrayals in qualitative inquiry: The road to found poetry and beyond. *Alberta Journal of Educational Research*, *48*(3), 229–239.

Butler-Kisber, L. (2019). Poetic Inquiry. In *Qualitative Inquiry: Thematic, Narrative and Arts-Based Perspectives* (2nd ed., pp. 95–113). SAGE Publications Ltd. https://doi.org/https://dx.doi.org/10.4135/9781526417978

Butler, J. (1988). Performative Acts and Gender Constitution: An Essay in Phenomenology and Feminist Theory. In *Source: Theatre Journal* (Vol. 40, Issue 4). https://about.jstor.org/terms

Butler, J. (2011). *Gender trouble: Feminism and the subversion of identity* (2nd ed.). Routledge.

Calderón, D., Delgado Bernal, D., Pérez Huber, L., Malagón, M. C., & Vélez, V. N. (2012). A Chicana Feminist Epistemology Revisited: Cultivating Ideas a Generation Later. In *Harvard Educational Review* (Vol. 82, Issue 4). http://meridian.allenpress.com/her/article-

pdf/82/4/513/2112186/haer_82_4_l518621577461p68.pdf?casa_token=w_dEpUPR4lwAAAAA:D3gOOJaB4bdmFtvEtPafznDtauuIH2vTe9IFjVnL--15DKazkVBxBqt7XzcPq_hwDb2F2qPdiQ

Campbell, P. (2016). Making physics connect. *Physics Education*, *51*(4), 15–17. https://doi.org/10.1088/0031-9120/51/4/040101

Carli, L. L., Alawa, L., Lee, Y. A., Zhao, B., & Kim, E. (2016). Stereotypes About Gender and Science: Women ≠ Scientists. *Psychology of Women Quarterly*, *40*(2), 244–260. https://doi.org/10.1177/0361684315622645

Carroll, M. A., & Barnes, E. F. (2015). Strategies for enhancing diverse mentoring relationships in STEM fields. *International Journal of Evidence Based Coaching and Mentoring*, *13*(1), 58–69. https://search.informit.org/doi/10.3316/INFORMIT.899386072831002

Carver, C. S., & Scheier, M. F. (1990). Origins and Functions of Positive and Negative Affect: A Control-Process View. *Psychological Review*, *97*(1), 19–35. https://doi.org/10.1037/0033-295X.97.1.19

Çetin, A. (2016). An Analysis of Metaphors Used By High School Students to Describe Physics, Physics Lesson and Physics Teacher. *European Journal of Physics Education*, *7*(2), 1–20. https://doi.org/10.20308/ejpe.35860

Charteris-Black, J. (2004). Corpus approaches to critical metaphor analysis. In *Corpus Approaches to Critical Metaphor Analysis*. Palgrave Macmillan. https://doi.org/10.1057/9780230000612

Chase, E. (2017). Enhanced member checks: Reflections and insights from a participant-

researcher collaboration. *Qualitative Report*, *22*(10), 2689–2703.

Chrousos, G. P., & Mentis, A. F. (2020). Imposter syndrome threatens diversity. *Science*, *367*(6479), 749–750. https://doi.org/10.1126/science.aba8039

Close, H. G., & Scherr, R. E. (2015). Enacting Conceptual Metaphor through Blending: Learning activities embodying the substance metaphor for energy. *International Journal of Science Education*, *37*(5–6), 839–866. https://doi.org/10.1080/09500693.2015.1025307

Cobern, W. W. (1993). Constructivism. *Journal of Educational and Psychological Consultation*, *4*(1), 105–112. https://doi.org/10.1207/s1532768xjepc0401_8

Cochran, G. L., & White, G. D. (2017). Unique voices in harmony: Call-and-response to address race and physics teaching. *The Physics Teacher*, *55*(6), 324–326. https://doi.org/10.1119/1.4999720

Cochran, G. L., & White, G. D. (2020). A second call-and-RESPONSE! *The Physics Teacher*, *58*(5), 292–293. https://doi.org/10.1119/1.5145516

Colby, S. R., & Bodily, B. H. (2018). Poetic Possibilities. *International Review of Qualitative Research*, *11*(2), 162–177. https://doi.org/10.1525/irqr.2018.11.2.162

Cooper, K. M., Downing, V. R., & Brownell, S. E. (2018). The influence of active learning practices on student anxiety in large-enrollment college science classrooms. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0123-6

Coughlin, S. S., Smith, S. A., & Fernandez, M. A. (2017). Overview of Community-Based Participatory Research. In S. S. Coughlin, S. A. Smith, & M. E. Fernandez (Eds.), *Handbook of Community-Based Participatory Research* (pp. 1–10). Oxford University Press.

https://doi.org/10.1093/acprof:oso/9780190652234.001.0001

Craig, S., Graesser, A., Sullins, J., & Gholson, B. (2004). Affect and learning: An exploratory look into the role of affect in learning with AutoTutor. *Journal of Educational Media*, *29*(3), 241–250. https://doi.org/10.1080/1358165042000283101

Crenshaw, K. (1989). Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. *University of Chicago Legal Forum*, *1989*(1). http://chicagounbound.uchicago.edu/uclfhttp://chicagounbound.uchicago.edu/uclf/vol1989/iss1/8

Crenshaw, K. (1991). Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color. *Stanford Law Review*, *43*(6), 1241. https://doi.org/10.2307/1229039

Cresswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry, Theory Into Practice,. *Theory into Practice*, *39*(25 Jun 2010), 124–130. https://doi.org/10.1207/s15430421tip3903

Cresswell, J. W., & Poth, C. N. (2016). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (4th ed.). SAGE Publications.

Daehnke, J. D. (2017). *Chinook Resilience: Heritage and Cultural Revitalization on the Lower Columbia River*. University of Washington Press. https://www.jstor.org/stable/j.ctvcwn341

Daehnke, J. D. (2019). A heritage of reciprocity: Canoe revitalization, cultural resilience, and the power of protocol. *Public Historian*, *41*(1), 64–77.

https://doi.org/10.1525/tph.2019.41.1.64

Danielsson, A. T. (2012). Exploring woman university physics students “doing gender” and “doing physics.” *Gender and Education*, *24*(1), 25–39. https://doi.org/10.1080/09540253.2011.565040

Dasgupta, D., Ferebee, D. M., & Michalewicz, Z. (2013). Applying Puzzle-based Learning to cyber-security education. *Proceedings of the 2013 Information Security Curriculum Development Conference, InfoSec CD 2013*, 20–26. https://doi.org/10.1145/2528908.2528910

de Guerrero, M. C. M., & Villamil, O. S. (2002). Metaphorical conceptualizations of ESL teaching and learning. *Language Teaching Research*, *6*(2), 95–120. https://doi.org/10.1191/1362168802lr101oa

Del Carmen Bello, B. (2018). *Exploring Latina and Hispanic Female Students' Sense of Belonging in STEM Majors Following a Belonging Intervention*. *September*, 180. https://search.proquest.com/docview/2137542674/abstract/A102BF0026824E16PQ/1

Delgado Bernal, D. (1998). Using a Chicana Feminist Epistemology in Educational Research. *Harvard Educational Review*, *68*(4), 555–583. https://doi.org/10.17763/haer.68.4.5wv1034973g22q48

Denzin, N. K., & Lincoln, Y. S. (2017). *The SAGE Handbook of Qualitative Research* (5th ed.). SAGE Publications.

Diekman, A. B., Clark, E. K., Johnston, A. M., Brown, E. R., & Steinberg, M. (2011). Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal

congruity perspective. *Journal of Personality and Social Psychology*, *101*(5), 902–918. https://doi.org/10.1037/a0025199

Ding, L., & Beichner, R. (2009). Approaches to data analysis of multiple-choice questions. *Physical Review Special Topics - Physics Education Research*, *5*(2), 020103. https://doi.org/10.1103/PhysRevSTPER.5.020103

Docktor, J., & Heller, K. (2008). Gender Differences in Both Force Concept Inventory and Introductory Physics Performance. *AIP Conference Proceedings*, *1064*(1), 15–18. https://doi.org/10.1063/1.3021243

Docktor, J. L., & Mestre, J. P. (2014). Synthesis of discipline-based education research in physics. *Physical Review Special Topics - Physics Education Research*, *10*(2), 020119. https://doi.org/10.1103/PhysRevSTPER.10.020119

Doscher, J. C., Hazari, Z., Potvin, G., & Klotz, L. (2015). *Sustainability Topics in Physics Education, Science Agency Beliefs and Physics Identity*. 99–102. https://doi.org/10.1119/perc.2015.pr.020

Dries, N., Pepermans, R., & Carlier, O. (2008). Career success: Constructing a multidimensional model. *Journal of Vocational Behavior*, *73*(2), 254–267. https://doi.org/10.1016/j.jvb.2008.05.005

Dweck, C. S., & Leggett, E. L. (1988). A Social-Cognitive Approach to Motivation and Personality. *Psychological Review*, *95*(2), 256–273.

Dyke, L. S., & Murphy, S. A. (2006). How we define success: A qualitative study of what matters most to women and men. *Sex Roles*, *55*(5–6), 357–371. https://doi.org/10.1007/s11199-

006-9091-2

Easterly, D. M., & Ricard, C. S. (2020). Reprint 2011: Conscious efforts to end unconscious bias: Why women leave academic research. *Journal of Research Administration*, *51*(1), 90–102.

England, B. J., Brigati, J. R., & Schussler, E. E. (2017). Student anxiety in introductory biology classrooms: Perceptions about active learning and persistence in the major. *PLoS ONE*, *12*(8), 1–17. https://doi.org/10.1371/journal.pone.0182506

Espinosa, L. L. (2011). Pipelines and pathways: Women of color in undergraduate stem majors and the college experiences that contribute to persistence. *Harvard Educational Review*, *81*(2), 209–240. https://doi.org/10.17763/haer.81.2.92315ww157656k3u

Etkina, E., Van Heuvelen, A., White-Brahmia, S., Brookes, D. T., Gentile, M., Murthy, S., Rosengrant, D., & Warren, A. (2006). Scientific abilities and their assessment. *Physical Review Special Topics - Physics Education Research*, *2*(2), 020103. https://doi.org/10.1103/PhysRevSTPER.2.020103

Faulkner, S. L. (2005). How to you know a good poem? Poetic re-presentation and the case for criteria. *1st International Congress of Qualitative Inquiry*, *May*. https://mafiadoc.com/poetic-representation-how-do-you-know-a-_5a2854291723dd48e85e5b73.html

Fencl, H., & Scheel, K. (2005). Engaging Students: An Examination of the Effects of Teaching Strategies on Self-Efficacy and Course Climate in a Nonmajors Physics Course. *Journal of College Science Teaching*, *35*(1), 20–24.

Ford, M. E. (1992). Personal Goals. In *Motivating Humans: Goals, Emotions, and Personal*

Agency Beliefs (pp. 83–122). SAGE Publications, Inc. http://sk.sagepub.com/books/motivating-humans

Geanellos, R. (2000). Exploring Ricoeur's hermeneutic theory of interpretation as a method of analysing research texts. *Nursing Inquiry*, *7*(2), 112–119. https://doi.org/10.1046/j.1440-1800.2000.00062.x

Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, Critical Agency, and Engineering: An Affective Model for Predicting Engineering as a Career Choice. *Journal of Engineering Education*, *105*(2), 312–340. https://doi.org/10.1002/jee.20118

Goertzen, R. M., Brewe, E., & Kramer, L. (2013). Expanded Markers of Success in Introductory University Physics. *International Journal of Science Education*, *35*(2), 262–288. https://doi.org/10.1080/09500693.2012.718099

Gonsalves, A. J. (2014). "Physics and the girly girl-there is a contradiction somewhere": Doctoral students' positioning around discourses of gender and competence in physics. *Cultural Studies of Science Education*, *9*(2), 503–521. https://doi.org/10.1007/s11422-012-9447-6

Gozzi Jr., R. (1996). The Jigsaw Puzzle As A Metaphor For Knowledge. *ETC: A Review of General Semantics*, *53*(4), 447–451. https://www.jstor.org/stable/42577767?casa_token=EnUO6SNPlmkAAAAA%3AtSxNZpvUjBeomhL3AUBy9KpAVEw9HB1QwZzDqFhlWf4_N9rsoa-QwwB_M75aI4pnQ9pnf27gakcdtH1Aqxdwm0famIhZmStZMKTbgdNnXZLSAADOYMI2&seq=5#metadata_info_tab_contents

Gray, K. E., Adams, W. K., Wieman, C. E., & Perkins, K. K. (2008). Students know what physicists

believe, but they don't agree: A study using the CLASS survey. *Physical Review Special Topics - Physics Education Research*, *4*(2), 1–10. https://doi.org/10.1103/PhysRevSTPER.4.020106

Guba, E. G., & Lincoln, Y. S. (1988). Do Inquiry Paradigms Imply Inquiry Methodologies? In D. M. Fetterman (Ed.), *Qualitative Approaches to Evaluating Education* (pp. 89–115). Praeger. http://images.lib.monash.edu.au/edf6006/04131082.pdf

Gupta, A. (2014). *Integrating emotions into fine-grained accounts of students' reasoning*. 23–26. https://doi.org/10.1119/perc.2013.inv.004

Gupta, A., Elby, A., & Danielak, B. A. (2018). Exploring the entanglement of personal epistemologies and emotions in students' thinking. *Physical Review Physics Education Research*, *14*(1), 10129. https://doi.org/10.1103/PhysRevPhysEducRes.14.010129

Hall, J. N. (2020). *Focus groups : culturally responsive approaches for qualitative inquiry and program evaluation*. Myers Education Press.

Hall, R. M., & Sandler, B. R. (1982). The Classroom Climate: A chilly one for women? *Project of the Status and Education of Women. Association of American Colleges.*

Harding, S. (2007). Feminist Standpoints. In *Handbook of Feminist Research* (2nd ed.). SAGE Publications. http://methods.sagepub.com/book/handbook-of-feminist-research/n3.xml

Harvey, L. (2015). Beyond member-checking: a dialogic approach to the research interview. *International Journal of Research and Method in Education*, *38*(1), 23–38. https://doi.org/10.1080/1743727X.2014.914487

Hawkesworth, M. E. (1989). Knowers, Knowing, Known: Feminist Theory and Claims of Truth.

Signs: Journal of Women in Culture and Society, *14*(3), 533–557. https://doi.org/10.1086/494523

Hazari, Z., Potvin, G., Lock, R. M., Lung, F., Sonnert, G., & Sadler, P. M. (2013). Factors that affect the physical science career interest of female students: Testing five common hypotheses. *Physical Review Special Topics - Physics Education Research*, *9*(2), 1–8. https://doi.org/10.1103/PhysRevSTPER.9.020115

Henderson, C., Dancy, M., & Niewiadomska-Bugaj, M. (2012). Use of research-based instructional strategies in introductory physics: Where do faculty leave the innovation-decision process? *Physical Review Special Topics - Physics Education Research*, *8*(2), 020104. https://doi.org/10.1103/PhysRevSTPER.8.020104

Herzog, H. (2005). On home turf: Interview location and its social meaning. *Qualitative Sociology*, *28*(1), 25–47. https://doi.org/10.1007/s11133-005-2629-8

Herzog, H. (2012). Interview location and its social meaning. In J. F. Gubrium, J. A. Holstein, A. B. Marvasti, & K. D. McKinney (Eds.), *The SAGE Handbook of Interview Research: The Complexity of the Craft* (pp. 207–218). SAGE Publications. https://doi.org/10.4135/9781452218403.n14

Hestenes, D., Wells, M., & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, *30*(3), 141–158. https://doi.org/10.1119/1.2343497

Hill, C., Corbett, C., & St. Rose, A. (2010). Why so few? Women in science, technology, engineering, and mathematics. American Association of University Women. In *American Association of University Women* (Vol. 5, Issue 3). AAUW.

http://eric.ed.gov/ERICWebPortal/recordDetail?accno=ED509653

hooks, bell. (1991). Theory as Liberatory Practice. *Yale Journal of Law and Feminism*, *4*(1).

hooks, bell. (1994). *Teaching to Transgress*. Routledge.

hooks, bell. (2014). *Feminism Is for Everybody: Passionate Politics* (2nd ed.). Routledge.

Jaggar, A. M. (1989). Love and knowledge: Emotion in feminist epistemology. *Inquiry (United Kingdom)*, *32*(2), 151–176. https://doi.org/10.1080/00201748908602185

Jefferson, G. (2004). Glossary of transcript symbols with an introduction. In G. H. Lerner (Ed.), *Conversation Analysis: Studies from the first generation* (pp. 13–31). https://doi.org/10.1075/pbns.125.02jef

Johnson, A., Brown, J., Carlone, H., & Cuevas, A. K. (2011). Authoring identity amidst the treacherous terrain of science: A multiracial feminist examination of the journeys of three women of color in science. *Journal of Research in Science Teaching*, *48*(4), 339–366. https://doi.org/10.1002/tea.20411

Johnson, A., Ong, M., Ko, L. T., Smith, J., & Hodari, A. (2017). Common Challenges Faced by Women of Color in Physics, and Actions Faculty Can Take to Minimize Those Challenges. *The Physics Teacher*, *55*(6), 356–360. https://doi.org/10.1119/1.4999731

Johnson, L. R. (2016). *Community-Based Qualitative Research*. SAGE Publications. https://us.sagepub.com/en-us/nam/community-based-qualitative-research/book243132

Keller, E. F. (1985). *Reflections on Gender and Science*. Yale University Press.

Kelly, A. M. (2016). Social cognitive perspective of gender disparities in undergraduate physics. *Physical Review Physics Education Research*, *12*(2), 1–13.

https://doi.org/10.1103/PhysRevPhysEducRes.12.020116

Kessels, U., Rau, M., & Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. *British Journal of Educational Psychology*, *76*(4), 761–780. https://doi.org/10.1348/000709905X59961

Ko, L. T., Kachchaf, Rachel, R., Hodari, A. K., & Ong, M. (2014). Agency of women of color in physics and astronomy: strategies for persistence and success. *Journal of Women and Minorities in Science and Engineering*, *20*(2), 171–195. https://doi.org/10.1615/JWomenMinorScienEng.2014008198

Kopp, R. R. (1995). *Metaphor therapy: Using client-generated metaphors in psychotherapy*. Brunner/Mazel. https://psycnet.apa.org/record/1995-97975-000

Kost-Smith, L. E. (2011). *Characterizing, modeling, and addressing gender disparities in introductory college physics.* [University of Colorado]. http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2012-99020-258&site=ehost-live

Kost, L. E., Pollock, S. J., & Finkelstein, N. D. (2009). Characterizing the gender gap in introductory physics. *Physical Review Special Topics - Physics Education Research*, *5*(1), 1–14. https://doi.org/10.1103/physrevstper.5.010101

Koster, R., Baccar, K., & Lemelin, R. H. (2012). Moving from research ON, to research with and for Indigenous communities: A critical reflection on community-based participatory research. *Canadian Geographer*, *56*(2), 195–210. https://doi.org/10.1111/j.1541-0064.2012.00428.x

Lakoff, G., & Johnson, M. (2003). *Metaphors We Live By* (2nd ed.). University of Chicago Press. https://doi.org/10.7208/chicago/ 9780226470993.001.0001

Lancor, R. (2014). Using Metaphor Theory to Examine Conceptions of Energy in Biology, Chemistry, and Physics. *Science and Education*, *23*(6), 1245–1267. https://doi.org/10.1007/s11191-012-9535-8

Lehtamo, S., Juuti, K., Inkinen, J., & Lavonen, J. (2018). Connection between academic emotions in situ and retention in the physics track: applying experience sampling method. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0126-3

Lewis, K. L., Stout, J. G., Pollock, S. J., Finkelstein, N. D., & Ito, T. A. (2016). Fitting in or opting out: A review of key social-psychological factors influencing a sense of belonging for women in physics. *Physical Review Physics Education Research*, *12*(2), 1–10. https://doi.org/10.1103/PhysRevPhysEducRes.12.020110

Leyva, L. (2016). An Intersectional Analysis of Latin@ College Women's Counter-stories in Mathematics. *Journal of Urban Mathematics Education*, *9*(2), 81–121.

Louis, R. A., & Mistele, J. M. (2012). The Differences in Scores and Self-Efficacy By Student Gender in Mathematics and Science. *International Journal of Science and Mathematics Education*, *10*(5), 1163–1190. https://doi.org/10.1007/s10763-011-9325-9

MacLeod, J. (2018). Ain't no makin' it: Aspirations and attainment in a low-income neighborhood, third edition. In *Ain't No Makin' it: Aspirations and Attainment in a Low-Income Neighborhood, Third Edition*. Taylor and Francis. https://doi.org/10.1201/9780429495458

Madsen, A., McKagan, S. B., & Sayre, E. C. (2013). Gender gap on concept inventories in physics: What is consistent, what is inconsistent, and what factors influence the gap? *Physical Review Special Topics - Physics Education Research*, *9*(2), 1–15. https://doi.org/10.1103/PhysRevSTPER.9.020121

Manning, S. M. (2018). Collaborative poetic processes: Methodological reflections on co-writing with participants. *Qualitative Report*, *23*(4), 742–757.

Marchand, G. C., & Taasoobshirazi, G. (2013). Stereotype Threat and Women's Performance in Physics. *International Journal of Science Education*, *35*(18), 3050–3061. https://doi.org/10.1080/09500693.2012.683461

Marshman, E. M., Kalender, Z. Y., Nokes-Malach, T., Schunn, C., & Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? *Physical Review Physics Education Research*, *14*(2), 20123. https://doi.org/10.1103/PhysRevPhysEducRes.14.020123

McCullough, L. (2004). Gender, context, and physics assessment. *Journal of International Women's Studies*, *5*(4), 20–30.

McGee, E. O., & Bentley, L. (2017). The Troubled Success of Black Women in STEM. *Cognition and Instruction*, *35*(4), 265–289. https://doi.org/10.1080/07370008.2017.1355211

Mejia, J. A., Revelo, R. A., Villanueva, I., & Mejia, J. (2018). Critical theoretical frameworks in engineering education: An anti-deficit and liberative approach. *Education Sciences*, *8*(4). https://doi.org/10.3390/educsci8040158

Miles, C. (2014). The rhetoric of managed contagion: Metaphor and agency in the discourse of

viral marketing. *Marketing Theory*, *14*(1), 3–18. https://doi.org/10.1177/1470593113506433

Miner, K. N., January, S. C., Dray, K. K., & Carter-Sowell, A. R. (2019). Is it always this cold? Chilly interpersonal climates as a barrier to the well-being of early-career women faculty in STEM. *Equality, Diversity and Inclusion*, *38*(2), 226–245. https://doi.org/10.1108/EDI-07-2018-0127

Modiano, P. (2001). *Catherine Certitude*. Godine.

Moser, K. S. (1999). Knowledge acquisition through metaphors.pdf. *Bildung Und Arbeit, Das Ende Einer Differenz?*, 141–152.

Moser, K. S. (2000). Metaphor Analysis in Psychology — Method , Theory , and Fields of Application. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *1*(2), 1–10. http://www.qualitative-research.net/index.php/fqs/article/view/1090

Moser, K. S. (2004). The role of metaphors in acquiring and transmitting knowledge. In M. Fischer, N. Boreham, & B. Nyhan (Eds.), *European perspectives on learning at work: the acquisition of work process knowledge* (pp. 148–163). Office for Official Publications of the European Communities.

Nissen, J. M., & Shemwell, J. T. (2016). Gender, experience, and self-efficacy in introductory physics. *Physical Review Physics Education Research*, *12*(2), 1–16. https://doi.org/10.1103/PhysRevPhysEducRes.12.020105

Norvilitis, J. M., Reid, H. M., & Norvilitis, B. M. (2002). Success in everyday physics: The role of personality and academic variables. *Journal of Research in Science Teaching*, *39*(5), 394–

409. https://doi.org/10.1002/tea.10028

Nubia-Feliciano, M. (2016). Dónde Pertenecemos? Narrative Analysis of Afro-Boricua Women's Experiences of Belonging Within and Beyond College. *ProQuest Dissertations and Theses*, 239. https://search.proquest.com/docview/1893494964?accountid=26642%0Ahttp://link.periodicos.capes.gov.br/sfxlcl41?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=dissertations+%26+theses&sid=ProQ:ProQuest+Dissertations+%26+Theses+Globa

Nur Ersozlu, Z. (2013). Mirror, mirror on the wall: Prospective mathematics and science teachers' use of metaphors to conceptualize and understand reflective thinking. *Anthropologist*, *16*(1–2), 7–19. https://doi.org/10.1080/09720073.2013.11891331

O'Connell, C., Eranki, P., & Landis, A. E. (2020). Empowering Women's Voices in STEM and Banishing the Inner Impostor. *International Journal of Diversity in Education*, *21*(1), 75–87. https://doi.org/10.18848/2327-0020/CGP/V21I01/75-87

Olusegun, S. (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning. *IOSR Journal of Research & Method in Education*, *5*(6), 66–70. https://doi.org/10.9790/7388-05616670

Ong, M. (2005). Body projects of young women of color in physics: Intersections of gender, race, and science. In *Social Problems* (Vol. 52, Issue 4, pp. 593–617). https://doi.org/10.1525/sp.2005.52.4.593

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher

education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, *55*(2), 206–245. https://doi.org/10.1002/tea.21417

Ong, M., Wright, C., Espinosa, L. L., & Orfield, G. (2011). Inside the double bind: A Synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, *81*(2), 172–208. https://doi.org/10.17763/haer.81.2.t022245n7x4752v2

Orser, B., & Leck, J. (2010). Gender influences on career success outcomes. *Gender in Management*, *25*(5), 386–407. https://doi.org/10.1108/17542411011056877

Packard, B. W.-L. (2016). *Successful STEM Mentoring Initiatives for Underrepresented Students*. Stylus Publishing, LLC.

Palic Sadoglu, G., & Uzun, S. (2014). Identifying Pre-Service Science and Technology Teachers' Perceptions Related to the Concept of Physics through Metaphors. *International Journal of Educational Research and Technology*, *5*(1), 7.

Paulson, E. J., & Armstrong, S. L. (2011). Mountains and Pit Bulls: Students' Metaphors for College Transitional Reading and Writing. *Journal of Adolescent & Adult Literacy*, *54*(7), 494–503. https://doi.org/10.1598/JAAL.54.7.3

Paulson, E. J., & Theado, C. K. (2015). Locating agency in the classroom: A metaphor analysis of teacher talk in a college developmental reading class. *Classroom Discourse*, *6*(1), 1–19. https://doi.org/10.1080/19463014.2014.888360

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research.

In *Educational Psychologist* (Vol. 37, Issue 2, pp. 91–105). https://doi.org/10.1207/S15326985EP3702_4

Pelch, M. (2018). Gendered differences in academic emotions and their implications for student success in STEM. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0130-7

Piaget, J. (1980). *The psychogenesis of knowledge and its epistemological significance*.

Pintrich, P. R. (2000). The Role of Goal Orientation in Self-Regulated Learning. *Handbook of Self-Regulation*, 451–502. https://doi.org/10.1016/b978-012109890-2/50043-3

Porter, A. M., & Ivie, R. (2019). *Women in Physics and Astronomy, 2019*. https://www.aip.org/statistics/reports/women-physics-and-astronomy-2019

Richardson, L. (2011). Poetic Representation of Interviews. In J. Gubrium & J. Holstein (Eds.), *Handbook of Interview Research* (pp. 876–891). SAGE Publications, Inc. https://doi.org/10.4135/9781412985437.n10

Ricoeur, P. (1974). Metaphor and the Main Problem of Hermeneutics. *New Literary History*, *6*(1), 95. https://doi.org/10.2307/468343

Ricoeur, P. (2016a). Hermeneutics and the human sciences: Essays on language, action and interpretation. In J. B. Thompson (Ed.), *Hermeneutics and the Human Sciences: Essays on Language, Action and Interpretation*. Cambridge University Press. https://doi.org/10.1017/CBO9781316534984

Ricoeur, P. (2016b). Metaphor and the Central Problem of Hermeneutics. In J. B. Thompson (Ed.), *Hermeneutics and the Human Sciences: Essays on Language, Action and*

Interpretation (pp. 127–143). Cambridge University Press. http://ebooks.cambridge.org/ref/id/CBO9781316534984

Robertson, A. D., Scherr, R. E., & McKagan, S. B. (2013). Paradigms in Physics Education Research. *ArXiv*, 1–22. http://arxiv.org/abs/1307.4135

Rosa, K., & Mensah, F. M. (2016). Educational pathways of Black women physicists: Stories of experiencing and overcoming obstacles in life. *Physical Review Physics Education Research*, *12*(2), 1–15. https://doi.org/10.1103/PhysRevPhysEducRes.12.020113

Rosa, K., & Mensah, F. M. (2021). Decoloniality in STEM research: (re)framing success. *Cultural Studies of Science Education*. https://doi.org/10.1007/s11422-020-10008-6

Ruiz, E. C. (2013). Motivating Latina Doctoral Students in STEM Disciplines. *New Directions for Higher Education*, *2013*(163), 35–42. https://doi.org/10.1002/he.20063

Sadler, P. M., & Tai, R. H. (2001). Success in introductory college physics: The role of high school preparation. *Science Education*, *85*(2), 111–136. https://doi.org/10.1002/1098-237x(200103)85:2<111::aid-sce20>3.3.co;2-f

Sakulku, J., & Alexander, J. (2011). The Impostor Phenomenon. In *The Journal of Behavioral Science* (Vol. 6, Issue 1). https://doi.org/10.14456/IJBS.2011.6

Saldaña, J. (2013). *The Coding Manual for Qualitative Researchers* (2nd ed.). SAGE Publications. www.sagepublications.com

Saldaña, J., & Omasta, M. (2021). *Qualitative Research: Analyzing Life: Saldana, Johnny, : 9781544372884: Amazon.com: Books* (2nd ed.). SAGE Publications, Inc.

Sandler, B. R., & Hall, R. M. (1986). The Campus Climate Revisited: Chilly for Women Faculty,

Administrators, and Graduate Students. *Project of the Status and Education of Women. Association of American Colleges.*, 30. http://eric.ed.gov/?id=ED282462

Sawtelle, V. (2011). *A gender study investigating physics self-efficacy* [Florida International University]. http://search.proquest.com/docview/952590865/abstract/6548788941674A96PQ/1

Sawtelle, V., Brewe, E., & Kramer, L. H. (2012). Exploring the relationship between self-efficacy and retention in introductory physics. *Journal of Research in Science Teaching*, *49*(9), 1096–1121. https://doi.org/10.1002/tea.21050

Scanlon, E. M. (2017). *Introductory Physics Students' Physics and Mathematics Epistemologies*. https://digital.library.txstate.edu/handle/10877/6752

Scherr, R. E., & Heron, P. R. L. (2016). *Education Metaphors We Live By*. 316–319. https://doi.org/10.1119/perc.2016.pr.074

Schiebinger, L. (1999). *Has Feminism Changed Science?* Harvard University Press.

Schmitt, R. (2015). Systematic Metaphor Analysis as a Method of Qualitative Research. *The Qualitative Report*, *10*(2), 358–394. https://doi.org/10.46743/2160-3715/2005.1854

Schutz, P. A., & DeCuir, J. T. (2002). Inquiry on emotions in education. *Educational Psychologist*, *37*(2), 125–134. https://doi.org/10.1207/S15326985EP3702_7

Secules, S., Gupta, A., Elby, A., & Tanu, E. (2018). Supporting the Narrative Agency of a Marginalized Engineering Student. *Journal of Engineering Education*, *107*(2), 186–218. https://doi.org/10.1002/jee.20201

Sinha, S., & Back, L. (2014). Making methods sociable: Dialogue, ethics and authorship in

qualitative research. *Qualitative Research*, *14*(4), 473–487. https://doi.org/10.1177/1468794113490717

Slank, S. (2019). Rethinking the Imposter Phenomenon. *Ethical Theory and Moral Practice*, *22*(1), 205–218. https://doi.org/10.1007/s10677-019-09984-8

Smith, L. T. (2021). *Decolonizing Methodologies: Research and Indigenous Peoples* (Third). Zed Books Ltd.

Solórzano, D. G. (1998). Critical race theory, race and gender microaggressions, and the experience of chicana and chicano scholars. *International Journal of Qualitative Studies in Education*, *11*(1), 121–136. https://doi.org/10.1080/095183998236926

Solórzano, D. G., & Yosso, T. J. (2002). Critical Race Methodology: Counter-Storytelling as an Analytical Framework for Education Research. *Qualitative Inquiry*, *8*(1), 23–44. https://doi.org/10.1177/107780040200800103

Spencer, D. (2009). *Card Sorting: Designing Usable Categories*. Rosenfeld Media.

Spencer, D., & Warfel, T. (2004). Card sorting: a definitive guide. *Boxes and Arrows*, 2.

Spencer, S. J., Logel, C., & Davies, P. G. (2015). *Stereotype Threat*. https://doi.org/10.1146/annurev-psych-073115-103235

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype Threat and Women's Math Performance. *Journal of Experimental Social Psychology*, *35*(1), 4–28. https://doi.org/10.1006/jesp.1998.1373

Steele, C. M. (1997). A Threat in the Air: How stereotypes shape intellectual identity and performance. *American Psychologist*, *52*(6), 613–629.

Stetzik, L., Deeter, A., Parker, J., & Yukech, C. (2015). Puzzle-based versus traditional lecture: Comparing the effects of pedagogy on academic performance in an undergraduate human anatomy and physiology II lab. *BMC Medical Education*, *15*(1), 1–11. https://doi.org/10.1186/s12909-015-0390-6

Tajmel, T. (2019). Pathways, intersections and leaky pipelines: the cognitive function of metaphors for research on STEM careers. *Cultural Studies of Science Education*, *14*(4), 1105–1113. https://doi.org/10.1007/s11422-018-9893-x

Tan, H., Wilson, A., & Olver, I. (2009). Ricoeur's Theory of Interpretation: An Instrument for Data Interpretation in Hermeneutic Phenomenology. *International Journal of Qualitative Methods*, *8*(4), 1–15. https://doi.org/10.1177/160940690900800401

The AIP National Task Force to Elevate African American Representation in Undergraduate Physics & Astronomy (TEAM-UP). (2020). *The Time Is Now: Systemic Changes to Increase African Americans with Bachelor's Degrees in Physics and Astronomy*.

Tomas, L., Rigano, D., & Ritchie, S. M. (2016). Students' regulation of their emotions in a science classroom. *Journal of Research in Science Teaching*, *53*(2), 234–260. https://doi.org/10.1002/tea.21304

Towns, M. (2010). Where Are the Women of Color? Data on African American, Hispanic, and Native American Faculty in STEM. *Journal of College Science Teaching*, *39*(4), 8.

Traweek, S. (2009). *Beamtimes and lifetimes*. Harvard University Press.

Traxler, A., Henderson, R., Stewart, J., Stewart, G., Papak, A., & Lindell, R. (2018). Gender fairness within the Force Concept Inventory. *Physical Review Physics Education Research*,

14(1), 10103. https://doi.org/10.1103/PhysRevPhysEducRes.14.010103

Traxler, A. L., Cid, X. C., Blue, J., & Barthelemy, R. (2016). Enriching gender in physics education research: A binary past and a complex future. *Physical Review Physics Education Research*, *12*(2), 1–15. https://doi.org/10.1103/PhysRevPhysEducRes.12.020114

Tuminaro, J., & Redish, E. F. (2007). Elements of a cognitive model of physics problem solving: Epistemic games. *Physical Review Special Topics - Physics Education Research*, *3*(2), 020101. https://doi.org/10.1103/PhysRevSTPER.3.020101

Turner, J. H. (2007). Human emotions: A sociological theory. In *Human Emotions: A Sociological Theory*. Routledge, Taylor & Francis Group. https://doi.org/10.4324/9780203961278

Tynjälä, P. (1999). Towards expert knowledge? A comparison between a constructivist and a traditional learning environment in the university. *International Journal of Educational Research*, *31*(5), 357–442. https://doi.org/10.1016/S0883-0355(99)00012-9

Vygotsky, L. S. (1962). *Thought and language (E. Hanfmann & G. Vakar, trans.)*. Cambridge, ma: mit Press.

Wang, J., & Hazari, Z. (2018). Promoting high school students' physics identity through explicit and implicit recognition. *Physical Review Physics Education Research*, *14*(2), 20111. https://doi.org/10.1103/PhysRevPhysEducRes.14.020111

Weiner, B. (1985). An Attributional Theory of Achievement Motivation and Emotion. *Psychological Review*, *92*(4), 548–573. https://doi.org/10.1037/0033-295X.92.4.548

Wilson, Z. S., Holmes, L., deGravelles, K., Sylvain, M. R., Batiste, L., Johnson, M., McGuire, S. Y., Pang, S. S., & Warner, I. M. (2012). Hierarchical Mentoring: A Transformative Strategy for

Improving Diversity and Retention in Undergraduate STEM Disciplines. *Journal of Science Education and Technology*, *21*(1), 148–156. https://doi.org/10.1007/s10956-011-9292-5

Zamarripa Roman, B., Vary Schwandes, A., & Chini, J. J. (2020). *Attending to emotion in a metaphor for success in physics with poetic analysis*. https://doi.org/10.1119/perc.2019.pr.zamarripa_roman